DOCUMENTATION OF THE CANYON CREEK FIRE
(Volume 1)

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PREFACE

by Jerry T. Williams, Fire Management Officer
Lolo National Forest

The Canyon Creek Fire was placed in prescription status under authority of a fire management plan approved in 1981. The fire, although initially managed as a prescribed natural fire within the Bob Marshall Wilderness Complex in western Montana, was eventually declared a wildfire. It subsequently exhibited some of the most severe fire behavior and rapid growth rates ever documented in the United States. This report documents the environmental conditions influencing the Canyon Creek Fire and describes its growth.

The following report reflects some of the challenges and dilemmas confronting land management agencies charged with maintaining the wilderness resource. Following the summer of 1988, the National Park Service and the U.S. Forest Service were widely criticized for their "let burn" policies. Although the debate focused on fire management policies, it may have more appropriately been centered on wilderness policies. The 1964 Wilderness Act provides for specially identified and managed lands where primeval characteristics and influences are retained and which appear to have been affected primarily by the forces of nature. In the Northern Rocky Mountains, fire's role is a dominant feature of the landscape, having influenced the maintenance or establishment of nearly all coniferous forests we see and enjoy today.

Across vast wilderness areas in the Northern Rockies, fire plays a stand replacement role wherein crown fires take out older trees that are replaced by younger stands. Thus, cycling forests at 50- to 150-year intervals. In these ecosystems, under the right combination of forest age, drought, and weather, the stand replacement event occurs under extreme burning conditions, well outside man's ability to control. It is the fundamental nature of these forest types to periodically cycle under severe conditions, regardless of management strategies or plans. In those forest ecosystems where fire plays a stand maintenance role, such as low elevation ponderosa pine, fire is more frequent, resulting in burning conditions that are often moderate and more easily controlled.

In wilderness areas characterized by even-aged stands subject to stand replacement burning lies the essential dilemma affecting the prescribed natural fire program. Given the fire behavior that results, how do managers allow for the stand replacement event inside wilderness within reasonable limits of risk to those values surrounding wilderness? The revised fire management plan for the Bob Marshall Wilderness Complex is state-of-the-art in terms of risk management, but still the chance for another Canyon Creek Fire—adversely affecting future generations—remains.

Perhaps the larger question resulting from the wilderness fires of 1988 centers on society's acceptance of wild places and the forces of nature that keep them wild. That question may yet remain unanswered.

ABSTRACT

The Canyon Creek Fire was initially a free-burning natural prescribed fire within the Scapegoat Wilderness of north-central Montana, USA, managed by the United States Forest Service. The lightning-caused fire burned for 112 days through high elevation mixed conifer and lodgepole pine forests. During the life of the fire, six crown fire runs in excess of 4,000 acres occurred, the largest of which was during the burning period of September 6 and 7 which burned approximately 117,330 acres. This crown fire run burned through rugged mountainous terrain along an approximate 65 mile long fire line, covering a distance of about 21 miles in 5.5 hours. The crown fire run averaged approximately 2.9 mi/h, with peak rates-of-spread observed to be 9.0 mi/h under the influence of a surfacing low level jet stream. This is the greatest documented conifer forest crown fire rate-of-spread in the United States. The fire was being actively managed as a wildfire prior to this crown fire run and remained so until the fire was declared controlled October 14th under a cover of snow. Final within perimeter acreage of the Canyon Creek Fire was 188,071 acres.

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Section 1.0 Introduction

The fire season of 1988 vividly stands out in the memory of not only the individuals who were actively involved with the fires, but also through the media the entire world became aware to varying degrees of the ongoing, widespread fires burning throughout the western United States, from Utah, Colorado and California north into Oregon, Washington, Idaho and Montana. Most of the public and world's attention was focused on the wildfires burning within Yellowstone National Park. However, one of the largest fires in the western United States during 1988 received very little attention, the Canyon Creek Fire in the Scapegoat Wilderness of northwestern Montana (portions of the Lolo, Helena and Lewis & Clark National Forests).

This documentation (volume 1) and in-depth chronology (volume 2) of the Canyon Creek Fire has been developed from interviews with available individuals who were involved during critical periods of the fire, as well as from radio logs from the different Forest Service offices surrounding the fire. The radio logs in particular proved to be an important information source, especially in providing times and locations for particular fire events. Whenever possible, events documented have been cross referenced through interviews with participants, and reviews of more than one radio log. The purpose of this report is to document fire behavior and contributing environmental influences to the fire behavior. At times it is difficult to reference particular fire behavior events, especially during some of the later stages of the fire, without also referring to the suppression actions which were also taking place. However, it is not the purpose of this documentation to cover the various fire containment and suppression actions.

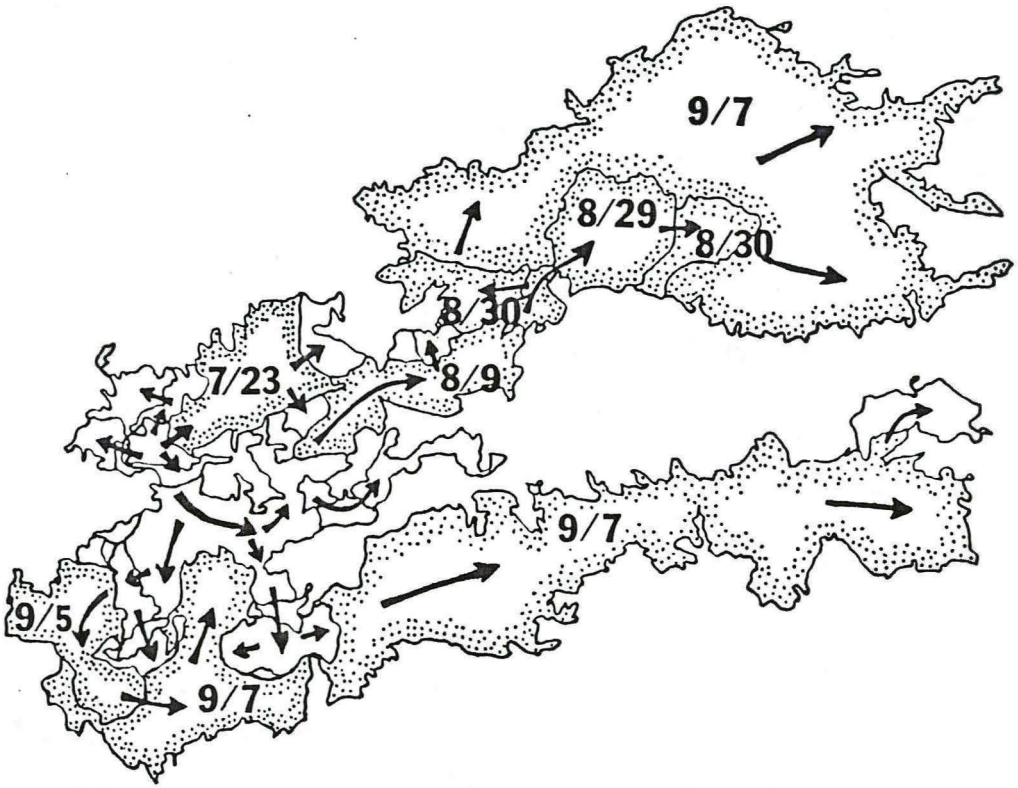
Daily fire perimeter growth for the Canyon Creek Fire was initially started by the Fire Behavior Analysts (FBA's) who were responsible for monitoring the fire at different intervals. The map these individuals created in most instances very closely matched burn patterns evident from aerial photographs for individual fire days. The fire perimeter growth maps presented in this document incorporates data from the early map drawn by the FBA's, interpretation of fire growth based on the aerial photography and changing fire severity patterns. Later stages of the fire also included infrared aerial photography, as well as information from interviews with personnel on the ground at the time. The FBA's fire perimeter growth map followed the fire through August 30. After 2 days of rapid perimeter growth, expansion essentially ceased on September 7 with mostly interior burning continuing for several days. There was a significant increase in fire activity on September 9 east of the Continental Divide in the Falls Creek and Josylin Basin areas that resulted in newly burned acreage. This date marked the end of the fire's perimeter expansion.

Daily fire perimeters showing the progression of the Canyon Creek Fire has been transferred to a topographic map so a better sense of fire behavior and spread can be gained, (enclosed pocket map, scale 1 inch = 1 mile). This particular map will be invaluable to the reader who is unfamiliar with the features and place names used to reference specific locations in this report. It is recommended that as the reader progresses through the report that the pocket map showing the daily fire perimeters be readily available for placing the activity for the specific period of time.

On most days the Canyon Creek Fire was not what might be termed a spectacular fire in terms of its fire behavior. On a typical day this prescribed natural fire (later in its life it would be declared a wildfire) did not even expand its perimeter, but just burned fuel within that perimeter that had been previously bypassed. Other days the fire would make a relatively small advance of 200-500 acres burning on a number of different fire fronts as a surface fire with periodic torching of trees, occasionally as a localized crown fire. The fire was performing its role within the natural wilderness

ecosystem as fire had for the preceding millennia. During these relatively inactive periods when the fire was progressing steadily but slowly the fire was "setting itself up," searching for that proper combination of fuel and topography, then waiting for environmental conditions to be conducive for rapid fire spread. During the 112 days that the Canyon Creek Fire lived, six burning periods produced large (4,000 acres or greater) rapidly spreading crown fire runs (fig. 1) (Appendix 1). It is these types of spectacular, large fire events within the Scapegoat Wilderness that has historically produced the largest, most characteristic type of fire produced vegetation and fuel mosaic on the Northern Rocky Mountain landscape.

Figure 1. Final perimeter map of the Canyon Creek Fire illustrating the direction of principal fire spread and the 6 days of major crown fire activity (stippled daily perimeters; Scale 1:375000). All dates represent single burning periods except September 7 which includes perimeter growth during the continuous crown fire activity starting on September 6 and whose spread ended during the early morning hours of September 7.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The first five large crown fire runs were associated with frontal systems, sometimes only minor upper level atmospheric disturbances. The last major increase in fire size during the burning period of the afternoon and evening of September 6, 1988 and the morning of September 7 was one of those rare cataclysmic examples of the forces of nature seldom witnessed by man. In this case the combination of a prolonged drought with subsidence inversions producing very dry fuel, persistent warm temperatures, and a surfacing jet-stream associated with a dry-cold front passage resulted in a conflagration, which at times traveled up to 9 mi/h and burned approximately 117,330 acres (about 183 square miles) over a 9-hour period of time (over 217 acres/minute). The various fire fronts traveled distances up to 21 miles across very rugged, mountainous terrain and out onto the adjacent rolling prairies burning extensive tracts of managed private as well as Federal and state lands outside of the wilderness boundary. In one 24-hour period the Canyon Creek Fire grew nearly as large as many of the Yellowstone Fires had during an entire summer season. In one burning period this fire etched its path across the landscape and into the history books as one of the largest fires ever documented in North America since European settlement (Guthrie 1936, Haines and Sando 1969). Certainly one of the largest fires to occur almost entirely in a natural fuel bed and from a single source ignition with an eventual final within perimeter fire acreage of 188,071 acres (294 square miles).

Most large historical fires are the result of the growth and merging of numerous fires under the influence of one or more wind events and frequently have their start or much of their initial spread in forest slash fuel. Little accurate information is available on fire behavior and fire weather for single burning period growth on large historical fires. In the United States the only large conflagration type fires with documented case histories are the 1967 Sundance Fire (+50,000 acres most of which burned during a 9-hour period; Anderson 1968, Finklin 1973) which occurred in northern Idaho, and the 1988 Red Bench Fire in northwestern Montana (14,683 during two burning periods; Bushey 1990). In Canada, large single burning periods have been documented in recent history including the 1980 DND-4-80 Fire in east-central Alberta with an initial run of about 18,525 acres in 6 hours (Alexander, Janz, and Quintellio 1983), multiple fire runs again in Alberta resulting in about 928,700 acres burned on August 27, 1981 (collectively called the "Black Thursday" Fires, Nimchuk 1983), and the 1986 Red Lake #7 Fire in Ontario which burned over 56,810 acres in an 8-hour period (Stocks and Flannigan 1987). All of these large fire runs have occurred under similar conditions: mature forests with heavy fuel, prior existence of a persistent high pressure ridge sometimes in combination with subsidence inversions causing widespread geographic drying of fuel, the arrival of a strong cold front with a reverse wind profile (Bryam 1954) sometimes associated with a low level jet stream (Schaefer 1957). This same set of conditions would occur on the Canyon Creek Fire during September 6. Many earlier large historical fires have evidently experienced significant single day increases in their burned acreage; however, much of the information concerning those particular days has been lost. Usually, the only fire behavior information available are the facts that the fires burned for months during a period of extended drought and had a large final acreage. Often a particular day is mentioned as being a particularly "bad fire day" in association with a wind event, such as October 8, 1871, in northeastern Wisconsin (Pestigo Fire), northeastern Illinois (Great Chicago Fire) and Michigan (Robinson 1882, Haines and Sando 1969, Haines and Kuehnast 1970); September 5, 1881 in northern Michigan (Bailey 1882, Schwartz 1990); September 11, 1902 in Washington State; August 20, 1910 in northern Idaho and western Montana (when a multiple fire run reportedly burned a strip 120 miles long by 20 to 35 miles wide, Guthrie 1936); and October 12, 1918 in northeastern Minnesota where an estimated 50 to 75 fires merged under a wind event (Richardson 1919). It is important that large crown fire behavior and the conditions leading up to that behavior be documented to better understand and predict their occurrence.

In the fire adapted ecosystems of the Northern Rocky Mountains and elsewhere, these types of large fire events will occur again, and it is important to be able to predict the potential of these events in advance to notify or evacuate fire crews and civilian populations down wind of the fire run. As far as is known, the potential for extreme, conflagration type fire behavior of the magnitude experienced on September 6, 1988 in the Northern Rocky Mountains on the Canyon Creek Fire and other fires had never been predicted before. The combination of weather and fuel conditions that were occurring had historical precedent for large crown fire events and led to the issuing of Fire Behavior Warnings, restrictions on public activities throughout Montana and the evacuation of communities downwind from these fires, starting 4-days prior to the event (Bushey 1989, 1990; Bushey and Mutch 1991).

The documentation of the Canyon Creek Fire took many different forms. One of the most important was interviewing many of the individuals who played an active role on the fire. This included fire fighters, fire lookouts, fire behavior analysts, fire weather forecasters, and many other U. S. Forest Service resource specialists who became involved at one stage or another. Out of these interviews and the many separate segments of the Canyon Creek Fire event, emerged a larger overall picture of what occurred on the fire. Frequently the timing of particular events was narrowed down with the aid of USDA Forest Service radio logs in which the "radio traffic" was dutifully recorded. Much rarer were the eye witness accounts of large fire phenomena back in the wilderness by trained fire behavior analysts or others. Part of the documentation process was the filtering out of unsubstantiated "facts" and opinions, of which there were many and varied. Other aspects of the documentation included an examination of the historical role of fire and fire induced forest succession in the Scapegoat Wilderness, a detailed review of weather records for the area and a comparison with 1987-1988 climatological data. Much of this more detailed information, along with a day-by-day chronology of the fire, is cataloged in a separate, second volume. The documentation in this report is a condensed summary on the Canyon Creek Fire phenomena and the influence of the local fuel, topography and environmental conditions on the fire behavior. During much of the later stages of the fire when it was under differing degrees of fire suppression or control, it is difficult not to intersperse some of the control efforts with the fire behavior information. This report is not meant as a documentation of the fire control tactics and strategy of the fire.

It is recommended that, because of the large area of highly dissected landscape on which the Canyon Creek Fire occurred, the reader frequently refer to the map which accompanies the text. Most references to fire location are by drainage or mountain name at that point on the map. It is interesting to note that some of the landscape features on the eastern side of the Scapegoat Wilderness historically reference an earlier 1889 large fire event: Blowout Mountain, Burnt Point and Red Mountain. Large scale fire is not an unknown phenomena in this geographic area, just infrequent and forgotten except for isolated remainders such as place names. A good idea of when and where the Canyon Creek Fire perimeter was located as the fire progressed is necessary to an understanding of the scale of this fire phenomena, as well as fire behavior on individual days.

This report will begin with a brief description of the Canyon Creek Fire's geographic area, then progress onto a short discussion of the vegetation/fuel groups (Fire Groups) found in the Scapegoat Wilderness and the general role of fire within the principal Fire Groups. The known fire history of the area is then presented. Following these subjects is a section dealing with the climatology and seasonal fire danger pattern of the Scapegoat Wilderness area and how the 1988 fire season was different from earlier fire seasons in this portion of the Northern Rocky Mountains. An understanding of each of these subjects and how they interact will aid in understanding the Canyon Creek Fire.

Section 1.1 Scapegoat Wilderness Area Topography

The Scapegoat Wilderness is an area of rugged landscape situated in northwestern Montana. The area designated for wilderness management includes a total of 236,100 acres. Another 31,600 acres are designated for RARE II evaluation (USDA 1981). The Scapegoat Wilderness is the southernmost portion of the geographic area commonly referred to as the Bob Marshall Wilderness complex. The wilderness complex includes the additional Bob Marshall and Great Bear Wilderness areas extending north toward, and contiguous with Glacier National Park.

Mountains within the wilderness and the adjacent eastern Rocky Mountain Front Range country are commonly considered part of the Sawtooth Range, and are a portion of the Overthrust Belt. The mountains are mostly limestone fault scarps. The front range is considered by many to be the most impressive physical feature within Montana with scarps abruptly rising up to 1,000 feet from the adjacent plains. Elevation within the Scapegoat Wilderness ranges from approximately 4,500 feet msl (mean sea level) at the lowest portion of the North Fork of the Blackfoot River to about 9,202 feet msl at the top of Scapegoat Mountain. Most mountain peaks in the area are generally between 7,500 and 8,800 feet msl with forested timberline being at approximately 7,800 feet msl.

A portion of the Continental Divide forms the backbone of the wilderness area and is located in the eastern third of the wilderness. Many of the peaks which form the Continental Divide within the Scapegoat Wilderness are barely above timberline with lower swales, saddles, and passes in most cases below the upper reaches of the coniferous forest. These relatively low lying, high elevation sites provide generally unrestricted freedom to potentially high intensity fire spread when the areas are covered by forest or grassland vegetation. The largest unvegetated areas are the peaks and ridges associated with the Scapegoat Mountain limestone massif (including 9,079 feet msl Flint Mountain, 8,523 feet msl Observation Point, and 8,523 feet msl Triple Divide), Crow Mountain (8,611 feet msl), and Caribou Peak (8,775 feet msl).

The North Fork of the Blackfoot River drains the western portion of the Scapegoat Wilderness and flows in a generally southerly direction. The North Fork of the Blackfoot has two principal side drainages besides the North Fork: the Dry Fork which flows from the northwest, and the East Fork which flows from the divide west. Many of the lesser tributaries which flow into these principal forks of the river tend to be oriented in a general east-west orientation on the west side of the Continental Divide. Canyon Creek near the origin of the Canyon Creek Fire is a northeast to east flowing tributary into the Dry Fork of the North Fork of the Blackfoot River near the northwest corner of the Scapegoat Wilderness.

On the east side of the divide the landscape is drained by several small streams which, for the most part, run in an east-southeasterly direction and merge with the Dearborn River which in turn, after leaving behind the Rocky Mountain Front and entering the prairies, flows into the Missouri River. Further north in the Scapegoat and still on the east side of the divide, several drainages flow to the northwest and empty into the Sun River.

Section 1.2 Scapegoat Wilderness Vegetation/Fuel Succession and Fire History

Section 1.2.1 Vegetation/Fuel Succession

Within and adjacent to the Scapegoat Wilderness there is a combination of vegetation patterns which have been classified as Fire Groups 0-2, and 4-10 (Davis and others 1980, Fischer and Clayton

1983, Fischer and Bradley 1987). Only Fire Group 7 (cool habitat types usually dominated by lodgepole pine, approximately 25% of the Scapegoat/Danaher Wilderness area [USDA 1981]) and Fire Group 9 (moist, lower subalpine habitat types, about 20% of the area [USDA 1981]) are prevalent. Fire Group 10 (cold, moist upper subalpine and timberline) is the next most common type covering about 10% of the area at the highest elevations (USDA 1981). The other Fire Groups occupy the remaining vegetated landscape and occur mostly as small inclusions scattered throughout the two most common Fire Groups.

Fire Group 7 contains two groups of habitat types. The first group consists of lodgepole pine climax series habitat types (and community types) that support essentially pure stands of lodgepole pine, which constitutes the persistent dominant species on these sites. The other group consists of those Douglas-fir, spruce, and subalpine fir habitat types that are usually found supporting lodgepole pine-dominated stands. Wildfires evidently recycle the stands before the lodgepole pine dies out, and frequently long before climax forest conditions are ever attained (fig. 2).

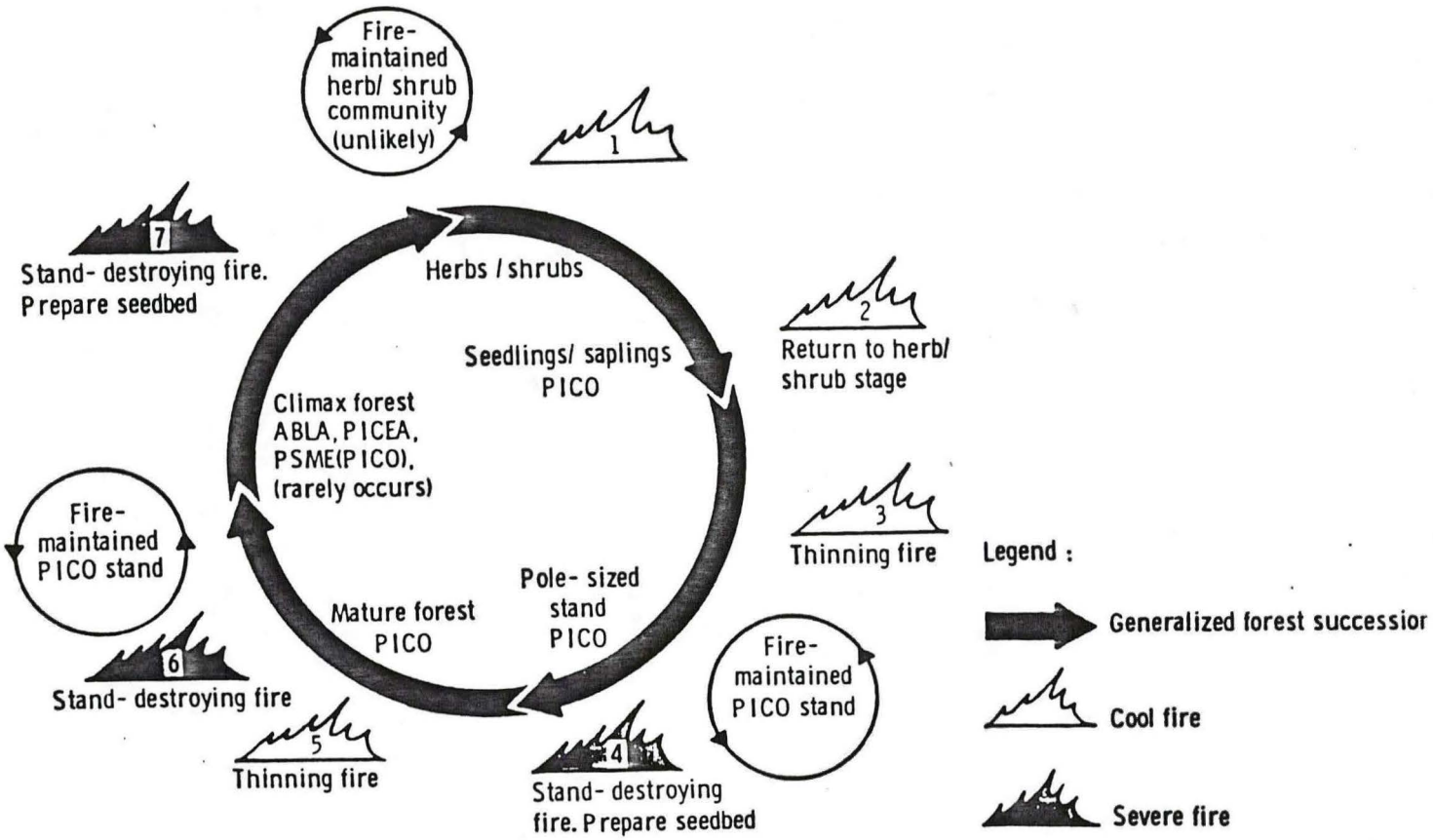


Figure 2. Generalized forest succession in Fire Group Seven: cool habitat types usually dominated by lodgepole pine (Fischer and Clayton 1983).

Subalpine fir, spruce, Douglas-fir, and white-bark pine occur in varying amounts with lodgepole pine on most sites. Undergrowth often consists of dense mats or layers of grasses or shrubs.

The average downed woody fuel loading in Fire Group 7 is about 15 to 18 tons/acre. Inventories have shown a range of about 3 to 35 tons/acre, but maximum loads may greatly exceed this range. Mathews (1980) reports extreme fuel loads in excess of 150 tons/acre in west-central Montana (East Fork of the Bitterroot River drainage near Sula, MT). A fuel inventory in the Scapegoat Wilderness indicated fuel in this Fire Group being light east of the Continental Divide with 3.4 tons/acre being considered typical, and fuel on the west side of the divide averaging between 4 and 12 tons/acre and being as high as about 20 tons/acre on wet sites which had remained unburned during the last century and still retained heavy surface fuel from earlier fires. Live fuel in this Fire Group can be a problem but not to the extent they are in some other Fire Groups. The primary live fuel consideration is related to the occurrence of dense patches or entire stands of young lodgepole pine with intermingled crowns and entire lower branches extending down to the surface fuel. When ignited under favorable conditions, such stands are usually removed in a few minutes.

On sites below 7,500 feet msl the role of fire in seral lodgepole forests is almost exclusively as an agent that perpetuates or renews lodgepole pine. Without periodic disturbance, the shade-tolerant species replace lodgepole because it does not regenerate well on duff or under shaded conditions. Fire interrupts the course of succession and increases the proportion of lodgepole with each burn. Within 50 to 100 years following a severe fire (fire with flame lengths greater than 11 feet that burns through the forest overstory and consumes large woody surface fuel and/or removes the entire duff layer over much of the area, organic matter incorporated in the upper soil layer may be consumed altering soil color) in a lodgepole-dominated stand, a reestablished lodgepole pine forest will exist even though shrubs and herbaceous cover may become dominant immediately following the burn.

Large scale stand-replacing fires play a major role in the ecology of lodgepole pine stands. The natural periodicity of severe fires in seral lodgepole stands probably ranges from less than 100 years to about 500 years (Hendrickson 1970). A frequency of reoccurring severe fires within portions of the Scapegoat Wilderness was estimated to be about 130 to 150 years (USDA 1981). This time estimate for fire return intervals in the Scapegoat Wilderness within this Fire Group may be high, especially during the last several hundred years. Recurring low severity fires (1 to 3 foot flame lengths which burns through surface fuel and have a minimal impact on the site) may thin the stand or otherwise rejuvenate it without doing serious damage. However, in stands greater than 60 to 80 years old, fuel will build up to hazardous levels due to natural thinning, mountain pine beetle outbreaks, dwarf mistletoe infestations, and fire-killed timber (snags) from previous fires. Eventually a chance ignition, followed by a major weather frontal passage with associated strong winds, sets off a conflagration. Such a fire may cover thousands of acres. Vast tracts of lodgepole can develop in this way as the serotinous cones open and shower the burn with seeds.

The almost exclusive dominance of lodgepole pine within the lodgepole pine community types is attributed in large part to fire. Pfister and others (1977) suggest the following reasons for the absence of other species on lodgepole pine climax series sites:

1. Historic, repeated fires over large areas may eliminate seed sources of potential shade-tolerant competitors.
2. Light ground fires may remove invading shade-tolerant competitors from the understory.
3. Dense stands may prevent regeneration of all conifers for up to 200 years in the absence of disturbance or stand deterioration.

4. Sites may be unfavorable for the establishment of other conifers.

Ayers (1901) in his travels through the Lewis and Clark Reserve, of which much would be the future Bob Marshall Wilderness complex, commented many times on this phenomena of forest succession following fire in Fire Group 7. The fire referred to occurred in 1889, 10 years prior to his visit:

> "In the valley of Willow Creek reproduction is especially good, and 40,000 young lodgepole pine to the acre are frequently found."
>
> "Some of the damper areas have a stock of Engelmann spruce and red fir [Douglas-fir] or larch. The areas subjected to repeated fires have very little new growth, and this is almost invariably lodgepole pine."
>
> "The effects of the fires upon the composition of the forest has been to increase the proportion of lodgepole pine. Probably 90 per cent of the stock coming is of this species". ... "On old burns some inclination to return to the original species was found, notably on the head of the North Fork of Blackfoot River, where spruce was found coming in under lodgepole pine. Larch, red fir, and white pine, too, sometimes reappear under lodgepole pine on old burns, but this reappearance is always slow ... ."

Red fir is one of the many early common names used for Douglas-fir which has been included in brackets.

Above 7,500 feet msl the role of fire in lodgepole pine forests appears to differ from the classic pattern. At these altitudes the fire season is relatively short in most years, productivity is low, and mountain pine beetle activity is inhibited by low temperatures and the short growing season. Romme (1980, 1982) has estimated a mean fire interval of 300 to 400 years for stand-replacing fires in subalpine forests of Yellowstone National Park. However, parts of that area have some extreme edaphic conditions such as soils composed of pure obsidian sand and the occurrence of severe year long frosts which create physiological conditions intolerable to any conifer except lodgepole pine. The spread of fire is often limited in the high elevation forests. Small, lightning caused fires burn out patches of forest several acres in area and then die out. The result may be a mosaic of age classes, not the uniform single-aged forests prevalent on many lower elevation sites (Day 1972).

Fire Group 9 (fig. 3) is a collection of moist and wet lower subalpine habitat types in the spruce and subalpine fir climax series. This Fire Group is found on all aspects but is most prevalent on north slopes. Frequently this Fire Group occurs in association with Fire Group 7.

Engelmann spruce is usually a major component of seral stands along with lodgepole pine and Douglas-fir. Older stands are usually dominated by subalpine fir and spruce although Douglas-fir and lodgepole may be well represented in the overstory. Whitebark pine occurs either accidentally or on some sites as a minor seral species. Abundant undergrowth occurs on these moist sites. Under normal moisture conditions, this lush undergrowth usually serves as an effective barrier to rapid fire spread.

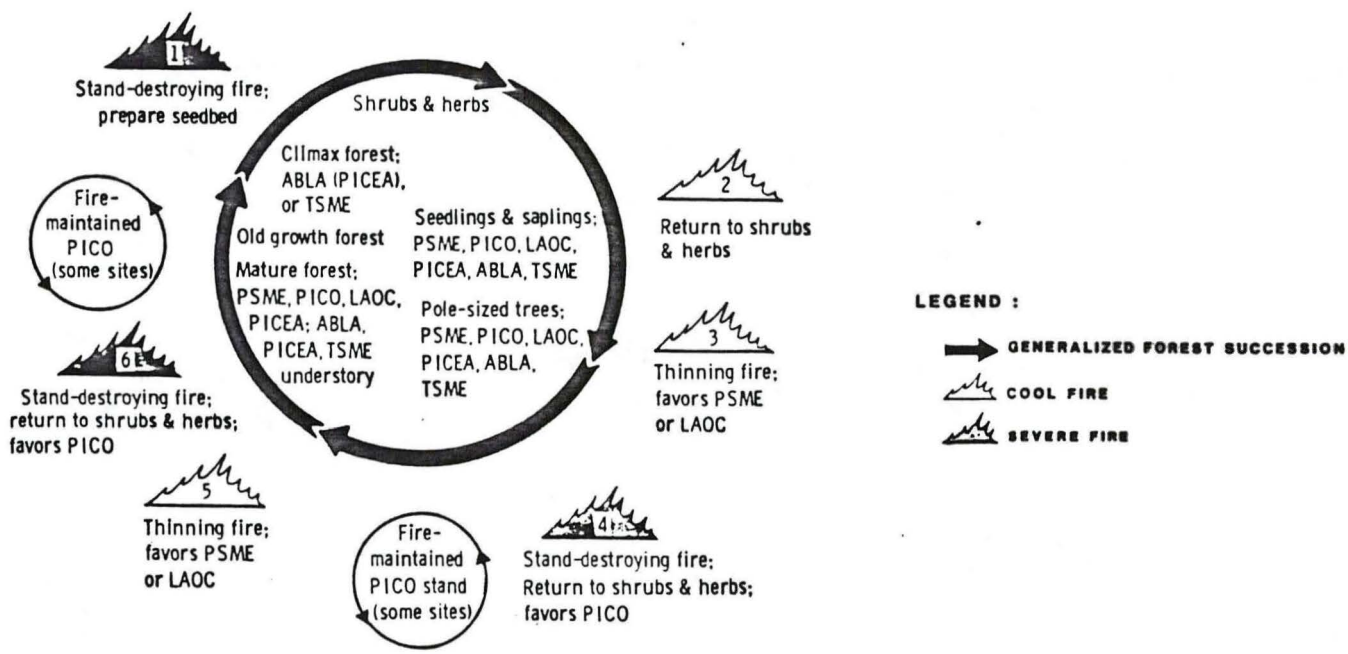


Figure 3. Generalized forest succession in Fire Group Eight: dry, lower subalpine habitat types; and in Fire Group Nine: moist, lower subalpine habitat types (Fischer and Bradley 1987).

Fire Group 9's downed dead woody fuel on the forest floor averages about 20 ton/acre east of the Continental Divide and about 25 tons/acre on the west side but may be much higher. The combination of deep duff and large accumulations of dead rotten fuel can result in intense surface fire during unusually dry moisture conditions. Where dense understories exist, such fires can easily spread to the tree crowns and remove the stand. Where surface fire does not crown, there is a good chance the overstory trees will be killed by cambium heating.

Fire history information for moist, lower subalpine habitat types is limited. Sneck (1977) studied the fire history within the subalpine fir/queencup beadlily (ABLA/CLUN) habitat type at Coram Experimental Forest in northwestern Montana. Mean fire-free intervals were found to vary with topography: intervals of greater than 117 years in valleys, 121 years on mountain slopes, and 146 years on lower alpine slopes. The average of these intervals is 128 years. Fires at Coram were reported to be small, moderately severe surface fires that occasionally crowned, especially near ridgetops. These fires thinned stands and prepared a mineral seedbed for conifer regeneration. Small, moderate severity fires (4 to 11 foot flame length that consumes the litter, upper duff, understory plants and foliage on understory trees, and most woody debris; occasional torching may occur if sufficient ladder fuel exists) are typical at Coram, which is mesic and has discontinuous fuel. Infrequent, widespread, severe fires have been documented for the somewhat drier surrounding habitats (Sneck 1977, Arno 1980). In Kananaskis Provincial Park in Alberta, Canada, stand-replacing fires were found to have occurred at average intervals of 90 years in relatively moist, lower subalpine types composed of subalpine fir, spruce, and lodgepole pine (Hawkes 1979). Relatively long fire-free intervals have been reported for spruce-fir forests on the Medicine Bow National Forest in southwestern Wyoming. Romme and Knight (1981) reported average fire-free intervals of 350 to 400 years in moist drainage bottoms, 300 years for the drier lodgepole pine covered upland sites. Freedman (1983) studied fire history within the *ABLA/CLUN* habitat type and *PICEA/CLUN* habitat type in the Goat Creek area of the upper Swan Valley near Condon, MT. Collectively, these moist sites had adjusted fire-free intervals (Arno and Peterson 1983) of about 30 years before 1905, with extremes between 10 and 100 years (Freedman and Habeck 1985). Freedman's study sites contained abundant ponderosa pine, which may account for the rather high fire frequencies.

The impact of fire on Fire Group 9 sites in the Scapegoat Wilderness is indicated by stand condition and species composition. The general absence of spruce, subalpine fir climax condition is evidence of frequent disturbance by past fires. The dominance of lodgepole pine, Douglas-fir, spruce, and larch west of the Continental Divide on many sites suggests these stands developed on a fire-created mineral soil seedbed.

The frequency of low severity surface fires in Group 9 is difficult to surmise. The moist nature of these sites would limit the opportunity for such fires in most years to a brief period during the summer or early fall. It seems reasonable to assume that lightning did in fact start such fires and that a certain amount of fuel reduction was accomplished. Left undisturbed, these fires probably flared up occasionally and created openings that favored establishment of seral species.

Section 1.2.2 Fire History

Little indepth fire history work has been accomplished within or near the Scapegoat Wilderness. Gabriel (1976) studied the fire history of the Danaher Creek drainage which is across a minor divide that separates the Scapegoat and Bob Marshall portions of the wilderness complex. This is the only study which uses the methods of Arno and Sneck (1977) to date fires using scars on tree boles. Information from Gabriel's study can be used to gain an understanding of potential

fire frequencies in the adjacent Dry Fork of the North Fork of the Blackfoot River portion of the Scapegoat Wilderness.

Interpretation of the fire/vegetation related comments, maps, and photographs recorded by Ayers (1901) during his 1899 field season in the Lewis and Clark Reserve contributes valuable information to the recent fire history of the Scapegoat Wilderness. Ayers's and Gabriel's work in conjunction with panoramic photographs taken during the 1930's and 40's from fire detection lookouts established in and near the wilderness, and USDA Forest Service Fire Atlas's for the area help define the impact of fire during the 1700-1900's.

Gabriel (1976) found that the southern half of the Danaher Creek drainage which was the closest portion of his study area to the Scapegoat Wilderness and the Canyon Creek Fire; in the Douglas-fir and spruce-subalpine fir zones at low to mid-slope elevations (Fire Groups 5 through 9), had a history of frequent surface fires creeping through lodgepole pine stands. These fires left many surviving trees, of which only a small percentage were burned severely enough to leave a fire scar. However, using this record for the area he was able to record a history of repeated fire occurrence back to the year 1749. Data from trees with multiple fire scars indicates that fires occurred at 20 to 40 year intervals in each lodgepole pine stand during the period from 1749 to 1944. Old stands of Douglas-fir recorded fewer fires which occurred in 1809, 1847, and more severe fires in 1854 and 1889, followed by another low to moderate severity fire in 1910. One Douglas-fir stand on the west slope of Concord Mountain, adjacent to the Scapegoat Wilderness, apparently burned four times within thirty years (1889, 1895, 1910, and 1919).

Burned stumps and a few old Douglas-fir trees on the divide between Danaher Creek and the Dry Fork of the North Fork of the Blackfoot River indicated that a fire about 1870 killed many of the trees in that stand and the fire of 1889 removed the rest. One hundred year old lodgepole pine now occupy the pass and carry scars from fires in 1910 and 1919.

Gabriel found only one area in the southern half of Danaher Creek which did not have any evidence of fire occurrence. This was a 240 to 280 year old mixed stand of Engelmann spruce, subalpine fir, Douglas-fir and lodgepole pine on the north flank of Danaher Mountain. Over the rest of his study area there was evidence that fires had changed the species and age composition of extensive forested areas in 1809, 1844-47, and 1889; fires in 1854-59, 1895 and 1910 probably had similar effects but on a smaller scale.

At higher elevations in what Gabriel also called the spruce-subalpine fir zone (Fire Group 10) he found abundant evidence of fire in the form of charcoal and dead snags. Fire scars were found in alpine larch, whitebark pine, and limber pine. He found that during the years 1809, 1847, 1919, and 1926 when large fires occurred at lower elevations they also burned in higher elevation sites. There was also evidence of numerous small fires at high altitudes.

Only the fires of 1889, 1910, and 1919 in the Danaher Creek drainage still had evidence existing that they had crossed the divide either into or from the Dry Fork of the North Fork of the Blackfoot River. Prior to the fires of 1844 insufficient evidence was available to even define rough fire boundaries within Danaher Creek, just occasional fire scars on old trees to show that a fire had occurred. However, since the two drainages on either side of the divide have similar climatic patterns and vegetation, we can assume that they had similar fire histories. During years when numerous or extensive lightning fire activity occurred in the Danaher Creek area, there were likely lightning caused fires across the divide in the Dry Fork as well.

Gabriel found that more evidence existed for the extent of the 1889 fires, than for any others, before or since. Evidence for this fire year was not only easily seen from fire scars but also from visible changes in forest height (age) and species composition. These 1889 fires also made it difficult to determine the boundaries of earlier fires, especially those of 1895, which may have reburned portions of the 1889 fires cleaning up dead and down woody fuel and recently established tree regeneration. The 1910 fires within this drainage also reburned some of the same areas for a third time and the only direct evidence for the 1895 fires was a few trees growing in protected locations that the later fires missed. There were also some areas of regeneration established shortly after 1885 that later fires did not burn.

During 1899 Ayers traveled through and described extensive portions of the 1889 fires. He also mapped burned areas which he saw had been "severe enough to kill all, or nearly, all the trees" during what he estimated to be the previous 40 years. Older fires had lost the features which distinguished them from the rest of the landscape as the regenerated forest gained in height. Low or moderate severity fires which did not remove the forest canopy were not mapped as burned, but as timberlands. In some areas Ayers mentioned that fires of this type were common. Ayers estimated that approximately 1,420 square miles had burned within the Lewis and Clark Forest Reserve and another 380 square miles adjacent to the Reserve for a total of 1,800 square miles during that forty year period (approximately 1860-1900). Of that total about 1,200 square miles burned in 1889.

> "That year was said to have been exceptionally dry, and the smoke from the forest fires almost unendurable. ...The fires have varied through all degrees of intensity. The severest have rushed through the tree tops consuming the needles and smaller twigs and igniting the humus lying upon the surface, which, even when burning slowly, has made fire enough to consume the smaller roots that were in the humus. The fires of 1889 were generally of this sort". (Ayers 1901)

As can be seen from his map much of the area now named the Scapegoat Wilderness was mapped as burned. An area much greater than the 1988 Canyon Creek Fire (fig. 4).

Figure 4. Enlarged detail from the lower right-hand corner of Ayers (1901) map of the Lewis and Clark Reserve. This map shows the present day Scapegoat Wilderness and surrounding region as it appeared in 1899. The 1988 Canyon Creek Fire has been outlined on the map to show the approximate extent of that fire and its relationship to burned and unburned topography as viewed by Ayers. Some distortion of the Canyon Creek Fire perimeter has resulted by trying to match forest burned or missed with the placement of physical features on Ayers's map. Of particular interest is the extent of canopy replacement fire in the coniferous forest in the forty years preceding 1899. Much of the burned landscape on Ayers's map in this region can be attributed to the 1889 fires, much of which reburned areas previously burned in early decades. Scale is approximately 1 inch = 8 miles.

Legend: Vertical Lines = Burned landscape within the previous +/-40 years. Olive = Forested area with less than 2000 M. boardfeet per acre. Green = Forested area with 2000 - 5000 M. boardfeet per acre. Dark Green = Forested area with 5000 - 10000 M. boardfeet per acre. Yellow/Orange = Prairie or areas dominated by native grasslands. Grey = Bare summits (rock).

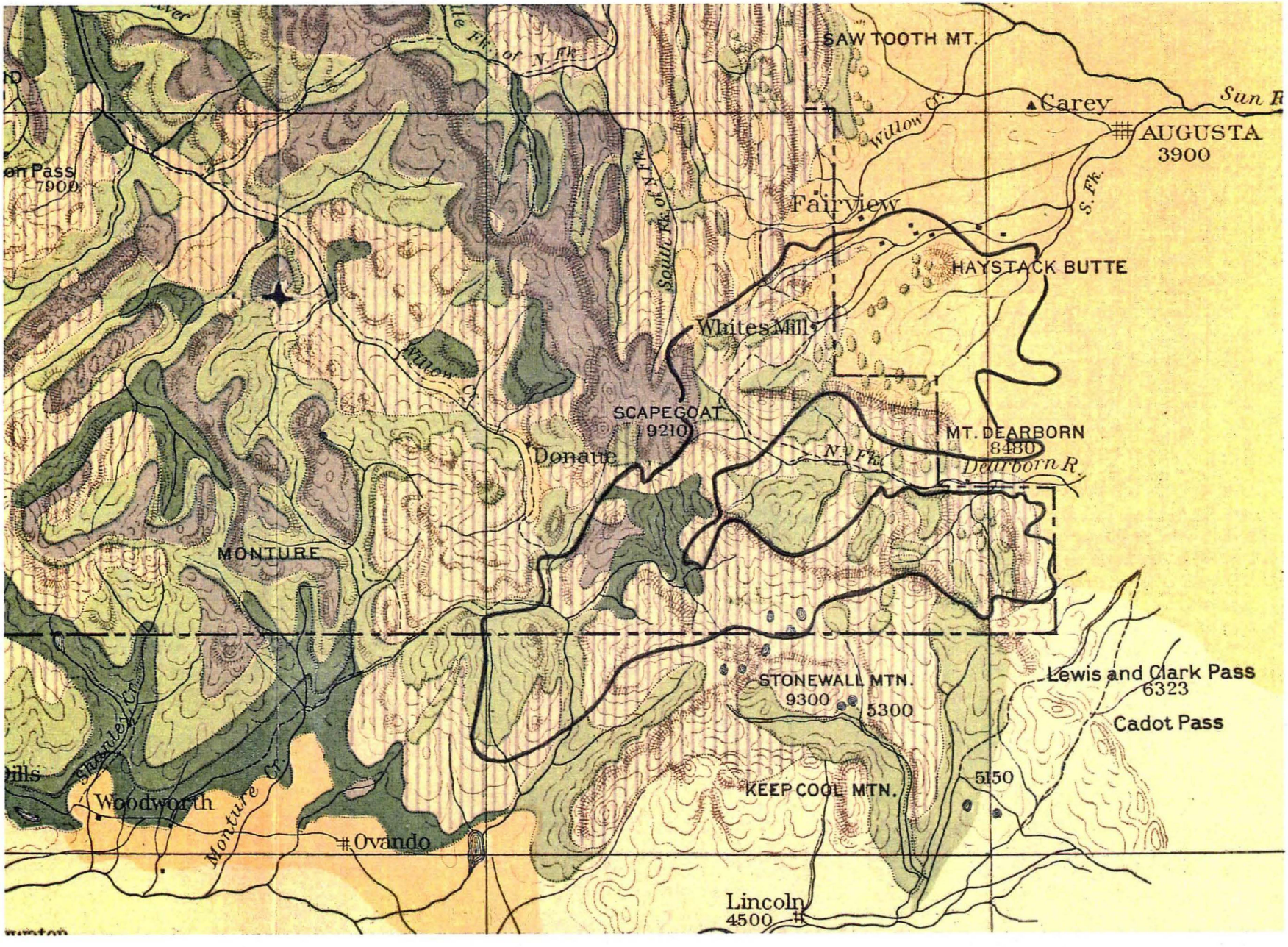

SAW TOOTH MT.
Carey
AUGUSTA
3900
Willow Cr.
S. Fk.
Fairview
HAYSTACK BUTTE
South Fk. of N. Fk.
Whites Mill
Arrow Cr.
SCAPEGOAT
9210
Donatte
MT. DEARBORN
8480
N. Fk.
Dearborn R.
MONTURE
STONEWALL MTN.
9300
5300
Lewis and Clark Pass
6323
Cadot Pass
5150
KEEP COOL MTN.
Stanley Cr.
Monture Cr.
Woodworth
Ovando
Lincoln
4500

Figure 5. Monthly percentage of total lightning caused fires for the Scapegoat Wilderness and surrounding portions of the Seeley Lake Ranger District (Lolo National Forest), and the Lincoln Ranger District (Helena National Forest).

Lightning Caused Fires

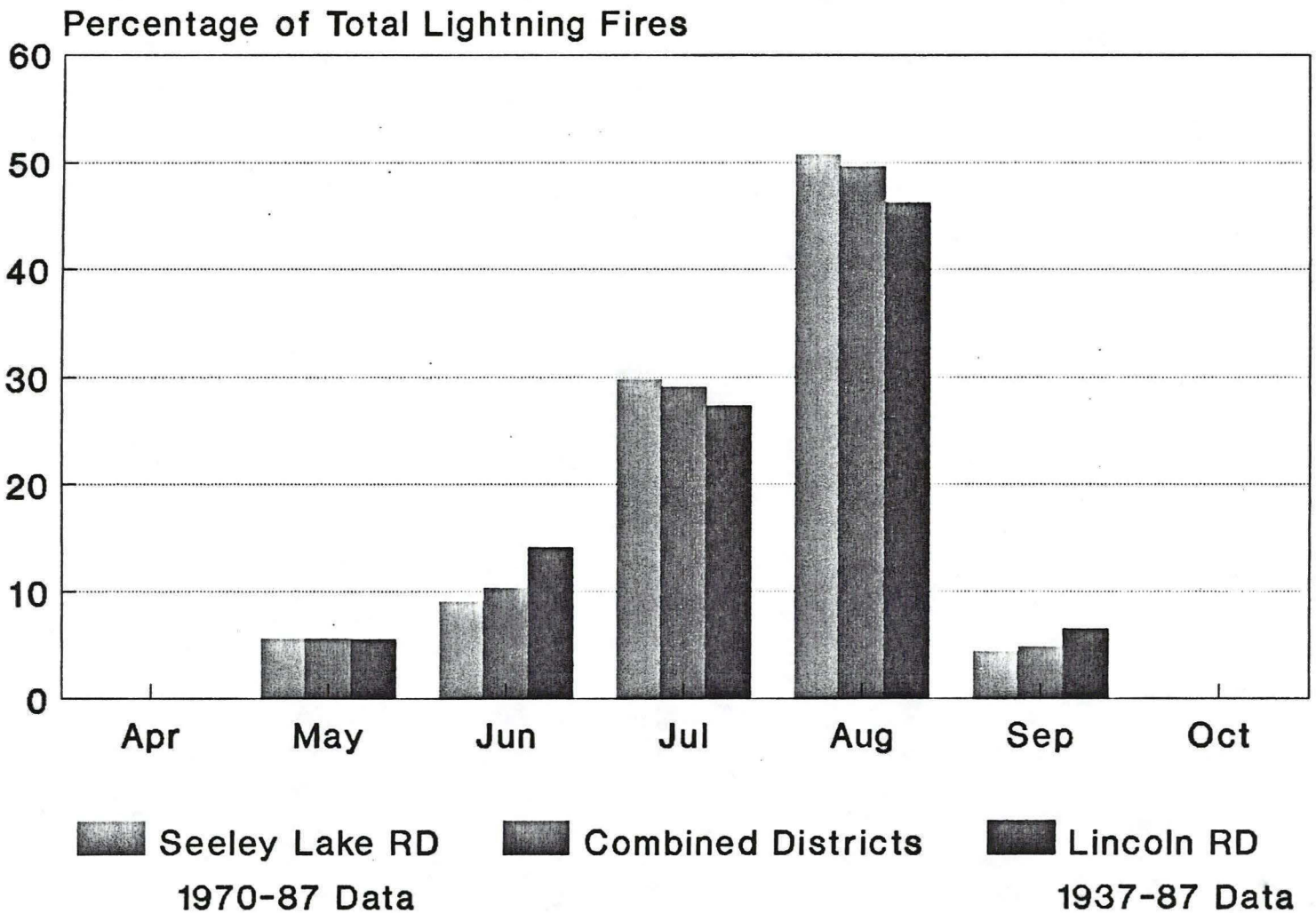


Figure 6. 1988 Water Year (October - September) difference from average of the average monthly temperatures at the Seeley Lake Ranger Station (Lolo National Forest), and the Lincoln Ranger Station (Helena National Forest).

Average Monthly Temperatures
1988 Water Year Differences from Average

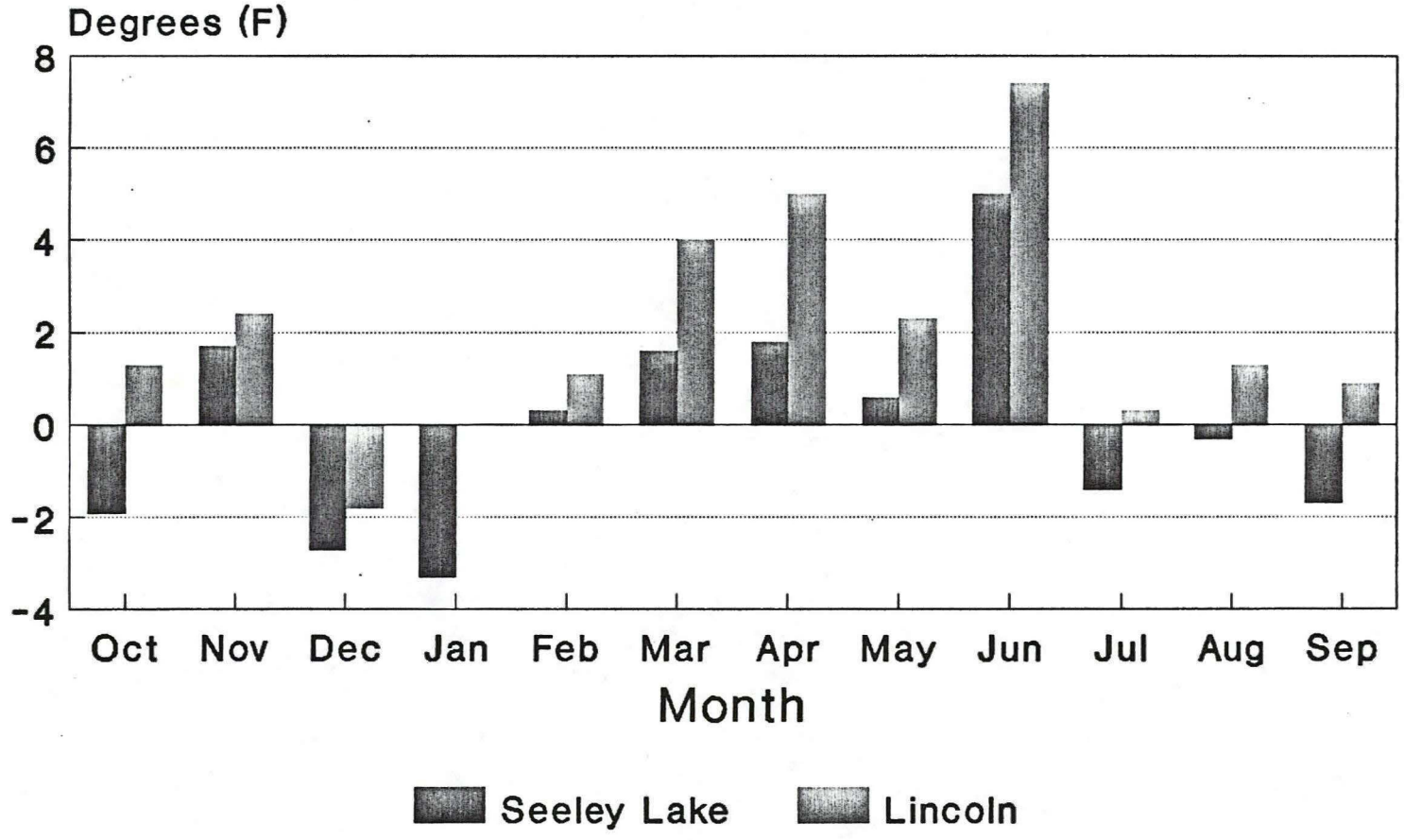
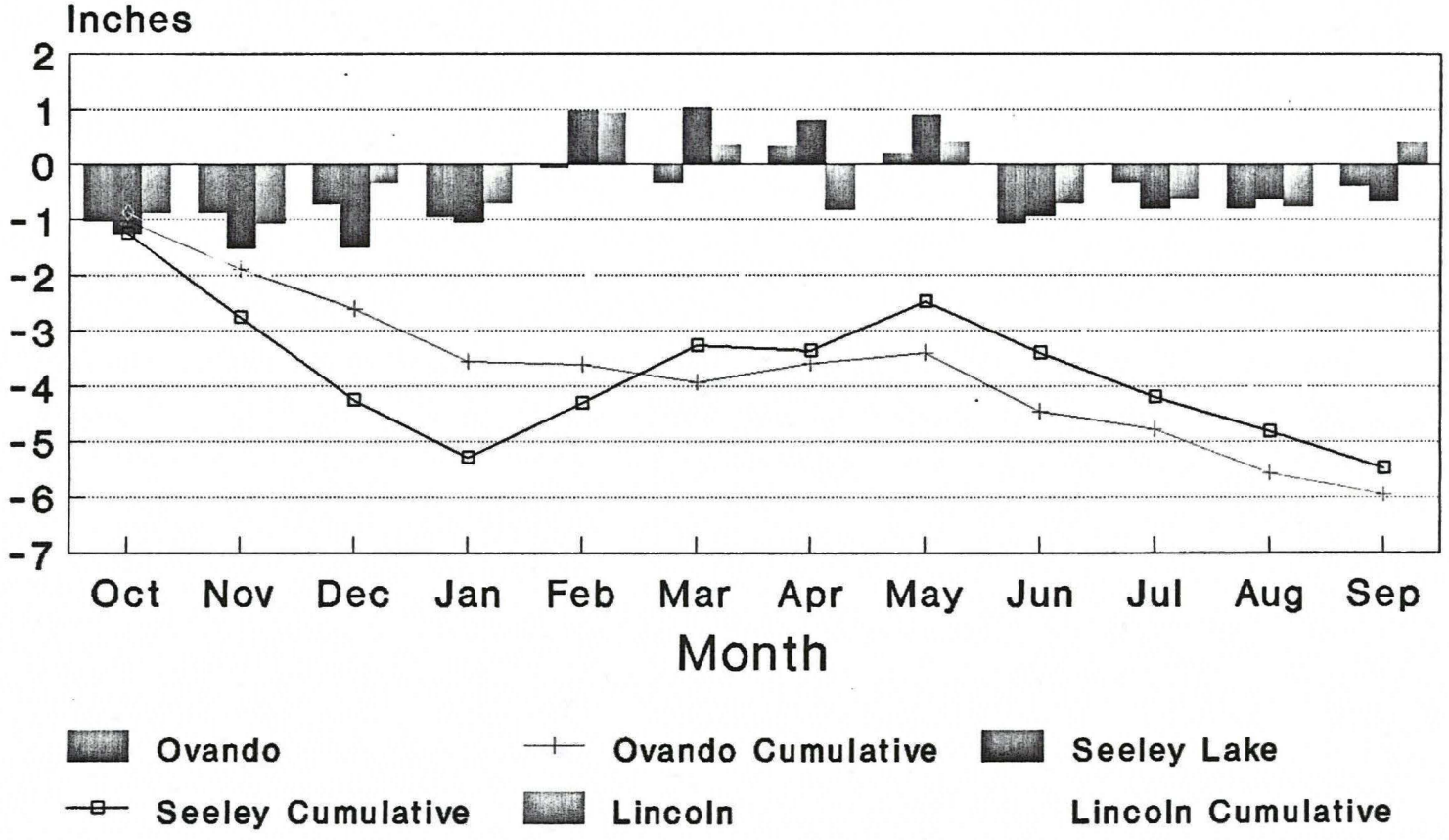


Figure 7. 1988 Water Year (October - June) difference from average monthly precipitation totals, and cumulative deficit for the Ovando station, Seeley Lake Ranger Station (Lolo National Forest), and the Lincoln Ranger Station (Helena National Forest).

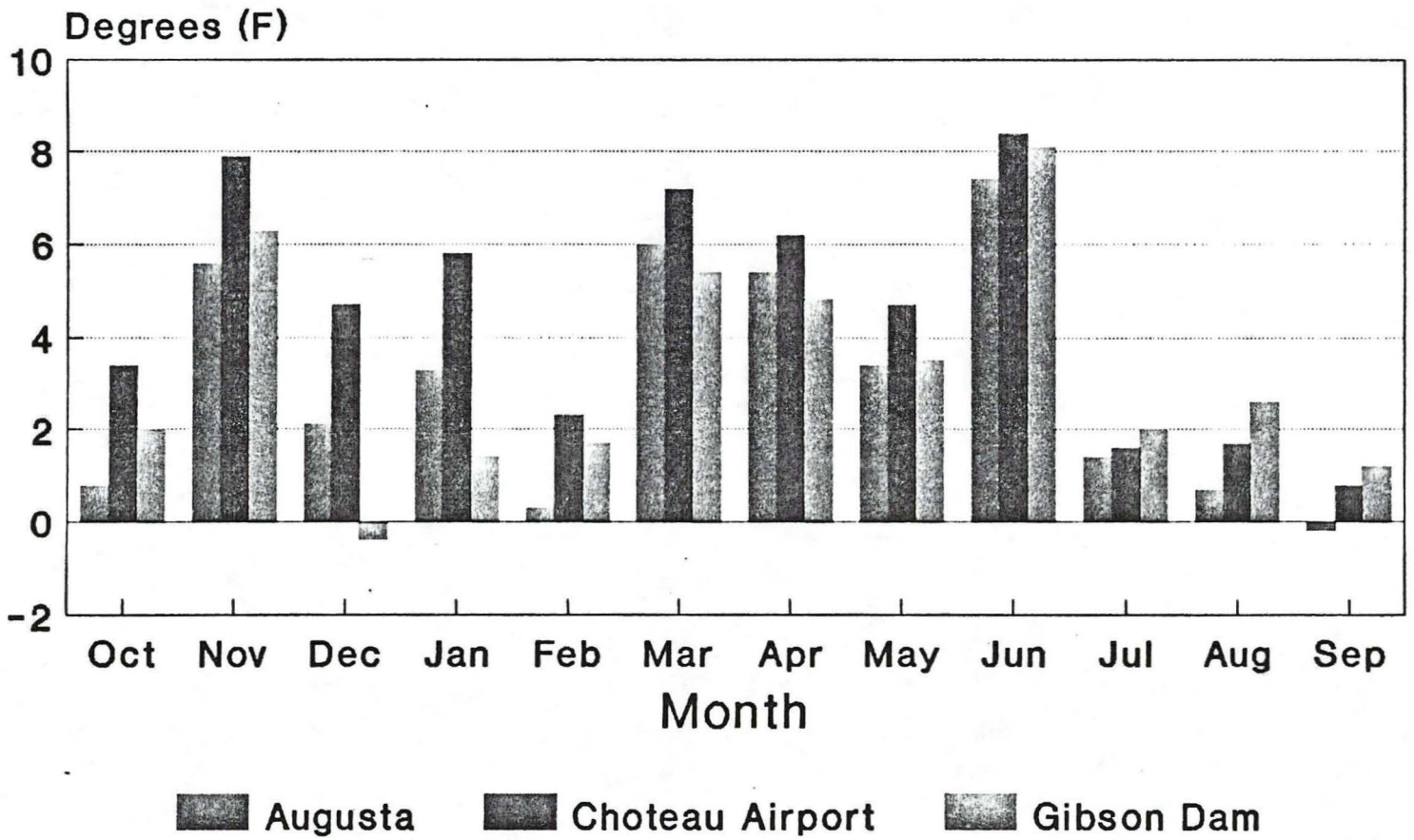
1988 Water Year Precipitation
Difference from Average



Stations west of the Continental Divide.

Figure 8. 1988 Water Year (October - June) difference from average of the average monthly temperature at the Augusta, Choteau, and Gibson Dam stations.

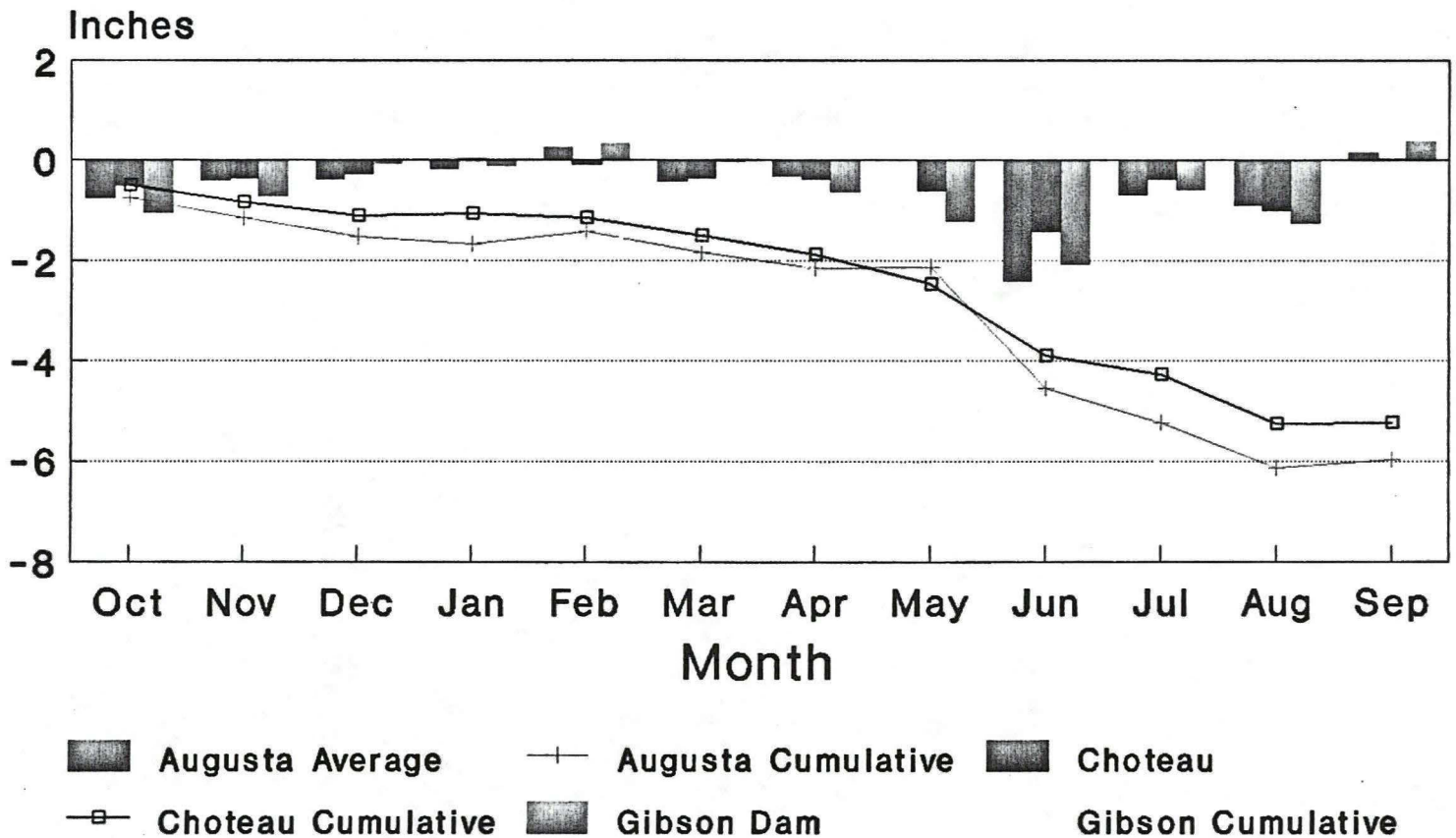
Average Monthly Temperatures
1988 Water Year Difference from Average



Stations east of the Continental Divide.

Figure 9. 1988 Water Year (October - June) difference from average monthly precipitation totals, and cumulative deficit for the Augusta, Choteau, and Gibson Dam stations.

1988 Water Year Precipitation
Difference from Average



Stations east of the Continental Divide.

However, a moisture deficit had been accumulating since the beginning of the Water Year (October-September) at all stations (all stations west of the divide had been in a steadily worsening drought since at least 1985, east of the divide since 1981 with 1985-1987 close to slightly above normal). The Main type season does not fit very well either because temperatures west of the divide returned to only slightly above normal, having peaked in June. However, July precipitation of -50% of normal at Lincoln and -76% at Seeley Lake does fit this severe fire season type. Again, a similar pattern was evident east of the divide, and the Water Year moisture deficit at all stations was increasing. The Late type doesn't fit because the early 1988 season was too warm and dry. The description of the later part of the Late type season does fit in terms of accumulating dry conditions peaking in late August or early September. The return to wetter than normal conditions, as predicted by Finklin (1985), by late September did develop except at Seeley Lake and Ovando. The 1988 fire season included major parts of all three severe fire season types; early season peak temperatures above normal, an accumulating moisture deficit (even after above normal moisture levels from February through May at most west side stations), main season worsening drought, and peak late season drought conditions. In all respects the 1988 fire season in the vicinity of the Scapegoat Wilderness developed into an unusual "Extended type" (this author's term) severe fire season which started almost imperceptibly in June with drying conditions and abnormally high temperatures, then gradually becoming dryer and combining with normal to slightly above normal warm summer temperatures steadily worsening until reaching a peak in early September. The fire season then declined rapidly in severity but burning conditions would extend well into October.

Typically, Finklin (1985) found that during severe seasons there is at least one 30-day period between June 1 and September that will have less than 25% of the average precipitation for the period. Also, the 30-day maximum temperatures will average 5 to 6 F degrees above normal. The Lincoln Ranger Station during the month of June had a monthly average maximum temperature +5.5 F degrees above average, July was +4.9 F degrees. Average high temperatures for the periods June-August and June-October in 1988 would both have average high temperatures over +6 F degrees from average. As already mentioned precipitation at this station was -30% of normal during June, and -50% during July. August moisture would be -60% of normal for the month.

Although Finkin (1985) did not examine the effect of dry, mild winter and early spring weather on the development of severe fire seasons, he does mention that early snowmelt and the drying of forested areas at this time of the year could be an important factor. A cover of snow did not arrive in much of the Scapegoat until early January of 1988 and was below average in snow water equivalent throughout the season. Warm late winter and spring temperatures removed what little snow had accumulated earlier than normal, exposing forest fuel to an extended drying season. Snow depth and moisture content, while being important, are not the principal factors affecting the moisture content of large fuel particles. McCammon (1976) clearly found that it takes 150 days under continual snow cover for 1000-Hour timelag fuel particles (3-8 inches in diameter) to attain maximum fiber saturation of approximately 39%. He also concluded that the duration of snowmelt is the major factor in liquid moisture absorption. Large fuel particles were already very dry following a warm, dry summer and fall in 1987. AFFIRMS thousand hour fuel moistures (moisture content in large fuel particles 3-8 inches in diameter) during October and November 1987 near the wilderness ranged from 11%-15%, while 100 hour fuel moistures (fuel particles 1 to 3 inches in diameter) were 12% to 16%. Significant precipitation did not arrive until the first week in January 1988. Assuming a snow cover from January 1 through June 15 at mid-elevations (Copper Camp just south of the Scapegoat Wilderness at 6950 feet msl was bare before June 15) provides a snow cover for 166 days. The warm temperatures of February through June certainly hastened the duration of snowmelt which was already low in snow-water equivalent and at least at the Lincoln

station below normal in depth. This would have allowed for an earlier than normal start to the large fuel particle drying process.

July was determined by Finklin (1985) to be the critical month in development of a severe fire season in the Northern Rocky Mountains. He found that 75% of the severe seasons examined in the Northern Region of the Forest Service had warm, dry Julys in respect to precipitation and average maximum temperatures. Only one season had a wetter and cooler than normal July. He also determined that few severe seasons had moist, cool Junes. The Canyon Creek Fire did not start to exhibit unusual fire behavior (different than previously observed within the Bob Marshall Wilderness complex during the Wilderness Prescribed Fire program) until July 23 after burning for 28 days. On this date the fire size grew by 9,322 acres during the first of several major crown fire runs.

An examination of the weather conditions during periods of extreme burning conditions when fires in the Northern Rocky Mountains (principally surface NFFL Fuel Models 9 and 10) started to exhibit running crown fire behavior was made using prescribed fires, wilderness wildfires and wildfires which had occurred on managed lands on the Flathead National Forest, Idaho Panhandle National Forest, and Glacier National Park. It was found that these fires commonly had temperatures 75 F degrees or greater, relative humidities of 25% or less and minimum wind speeds of approximately 9 MPH when the fires started to exhibit crowning behavior. If temperatures rose to 80 F degrees with the same relative humidities and minimum wind speeds the crown fires were usually well developed. Once initiated crown fire behavior could be maintained with lower temperatures and rising humidities if during a frontal passage strong winds persisted or strengthened. Most crown fires occurred between 75-80 F degrees, 15-25% RH and 9-20 MPH wind speeds. Using data from AFFIRMS weather stations surrounding the Canyon Creek Fire and stored at the National Fire Weather Data Library (NFWDL)(Fulman and Brink 1975) the percent occurrence of these combinations of weather conditions were examined (Lincoln 36 years [4,864 days of data]; Seeley Lake 36 years [3,625 days]; Gleason's Resort 28 years [3,222 days]). It was found that approximately 2% of the days in the historical fire season weather data met the criteria for the initiation of crown fire behavior at any particular station on either side of the Continental Divide. August was the most likely month for the combination of weather parameters to occur, followed by July. West of the divide these two months were followed by June then September, while east of the divide more days occurred in September than June. Combined with the low incidence of lightning caused fires, the low percentage of days with the proper combination of weather conditions would indicate that running crown fire behavior in the Scapegoat Wilderness is an unusual event. However, it is very evident that this type of fire behavior has been one of the principal ecological forces in developing the composition and structure of the vegetative communities in the Scapegoat Wilderness.

Section 1.3.2 Fire Danger

Fire danger is measured using several indices developed from daily weather measurements taken at AFFIRMS stations and made available through the National Fire Danger Rating System (NFDRS)(Deeming and others 1977). The Energy Release Component (ERC) and Thousand Hour Fuel Moisture will be the indices used for comparative purposes on the Canyon Creek Fire in this report.

ERC calculates the estimated potential available energy released per square foot during the flaming combustion zone using standardized fuel models. The ERC for fuel model G (short needle, closed canopy coniferous forest with heavy loads of dead and down timber [Deeming et al. 1974]) is

considered to be a good indicator of long term drying and is used as prescription guidelines in most manuals for prescribed natural fire prescriptions. These guidelines are usually discussed in terms of percentile level, usually the 80th and 90th percentile levels, as well as an actual, or daily, ERC number. The percentile levels are calculated from frequency distributions of historical ERC levels. For comparison purposes the percentile levels are calculated in this report for the 1973-1987 seasons, unless otherwise noted. Daily comparisons are made using an average 3-day running mean to smooth out irregularities.

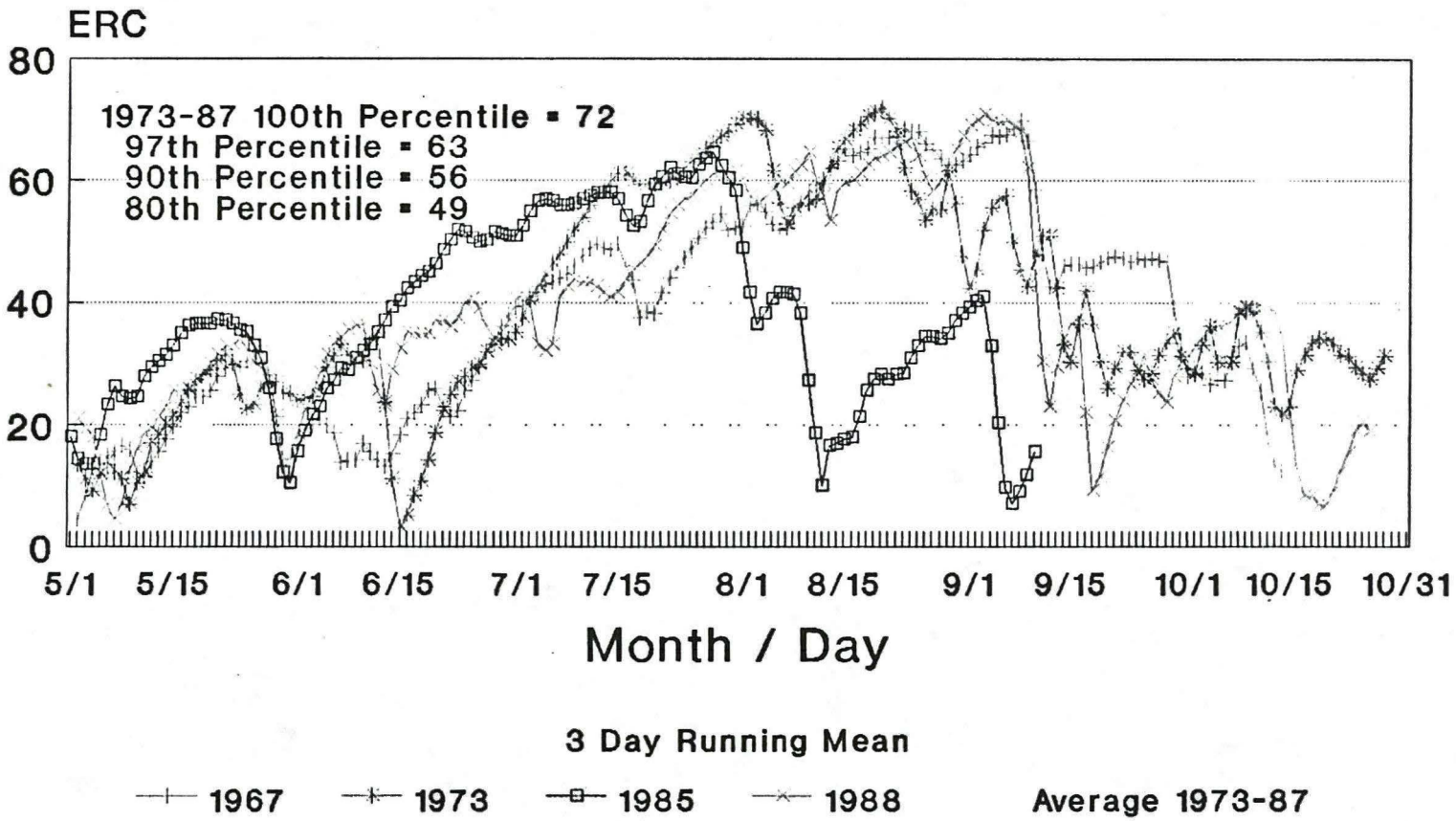
Thousand Hour Fuel Moisture is an index of fuel moisture for large fuel particles, commonly called 1,000-Hour timelag fuel. These particles are described as 3 to 8 inches in diameter either on or near the forest floor, or no more than 4 inches below the surface. A factor of 1,000 hours is used as a guideline for these fuels to lose an approximate 66% of their weight in moisture. This index is considered to be a good indicator of the severity of a medium drought event (4-6 months duration). A season minimum moisture level for Thousand Hour Timelag Fuel of 9% within Fuel Model G in the Northern Rocky Mountains is indicative of this type of drought event. It is highly unusual for fuel particles of this large size to drop to such low moisture levels (Bradshaw and others 1983). For ease of comparison the average 3-day running mean Thousand Hour Fuel Moisture was calculated using the same years as used with the ERC, 1973-1987.

Finklin (1985) found that severe fire danger seasons which he classified as an Early type typically reached the 70th percentile ERC level by June 20 and the 80th percentile by July 1. Late type seasons reached the 70th percentile by July 25 and the 80th between August 1 and 10. The downward curves for all three severe season types he found to be similar after September 1-10. Finklin described the 1967 severe wildfire season as "Late" on both side of the Continental Divide; 1973 was a Main type on the west side of the divide and not severe on the east side based on ERC (based on the ERC levels at the east side Gleason's Resort AFFIRMS station I would place that portion of the area east of the divide within a Main type season.) Using Finklin's classification system for the last previous severe season prior to the Canyon Creek Fire, 1985, and then 1988; placed 1985 on both sides of the divide as an early season, and 1988 as both Main and Late types west of the divide and a combination of Early, Main and Late types ("Extended type", author's term) on the east side. Examining only the high elevation fire lookout stations, all four severe fire danger years may be classified as the late Main type combined with an early Late type season.

The Lincoln Ranger Station is the location for the AFFIRMS station which provides the fire danger data used as a guide in the decision and monitoring process for wilderness fire in the Blackfoot Unit of the Scapegoat Wilderness, the unit in which the Canyon Creek Fire was initially located. At this station the ERC levels in late June of 1988 were well above average with only the 1985 Early type severe fire season having a greater level since 1967 (fig. 10). On the day of the Canyon Creek Fire lightning strike, June 25, the ERC level 3-day running mean was 40.6 (daily was 48)(Appendix 2).

Figure 10. Energy Release Component for the Lincoln Ranger Station, Helena National Forest; Seasonal Average 1973-1987, 1967, 1973, 1985, and 1988 severe fire danger seasons.

Energy Release Component
Lincoln Ranger Station (241904)



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Although this value was above the 80th percentile level of 33 (1973-1982 data base), the area's fire management plan provided for the fire's consideration as a prescribed natural start. Overcast conditions with scattered, locally heavy rain, impeded aerial detection and persisted over the region for several days. By the date the prescribed fire decision analysis was approved and signed, June 29, the ERC 3-day running mean had declined and was at 35.3 (daily was 32). After a short period of ERC stagnation the index again began to climb, attaining the 90th percentile level (ERC of 56) on July 23. On this date the Canyon Creek Fire made its first major crown fire run covering approximately 9,322 acres, the largest single day fire run inside the Bob Marshall Wilderness complex since the beginning of the prescribed natural fire program. Only on one later date prior to the final end of the season ERC decline, would the ERC level at Lincoln drop below the 90th percentile level during 1988. This station was above the 97th percentile level (ERC of 63) from August 19 through August 25, and again from August 30 through September 8. A peak of 71 was attained on September 3, 1988 (100th percentile level was 72). The seasonal average late August ERC peak is 43.4, below the 80th percentile level. Both the 1967 and 1988 severe fire danger seasons, as measured at the Lincoln station, were at nearly identical heights in late season ERC levels as they entered the first 10-day period of September. Both seasons also begun their precipitous end of the season decline about September 8 at this location.

The 1988 severe fire danger season on the east side of the Continental Divide as monitored at Gleason's Resort Station started much higher than any other severe season evaluated (fig. 11). The seasonal average maximum ERC level at Gleason's Resort is usually reached during late July and is about 29. The station briefly climbed above the 80th percentile level (ERC of 35) for six days beginning on June 20, then rapidly dropped back to below seasonal average before again attaining such ERC heights. Most severe seasons at this east side station finally move above their seasonal average during the first 6-day period in early July, in 1988 this event occurred on July 7. Previous severe fire danger seasons continually gained in ERC levels usually reaching the 97th percentile level (ERC of 48) by the end of July, 1988 would be no exception. The 1988 ERC peak at this site was reached on September 9 (ERC of 64.5), matching the highest level reached in recent severe seasons. 1988 would prove to be the longest sustained severe season in recent history and would still be above the 80th percentile level as late as October 3, finally returning to near normal levels after the middle of the month.

Thousand Hour Fuel Moisture levels during the last half of May and early June 1988 at the Lincoln Station were approximately 5% below the seasonal average of 23% (fig. 12). With the arrival of late June moisture, including the lightning storm which ignited the Canyon Creek Fire, the moisture level of the large fuel particles at this station rebounded back to near seasonal average. After this period of precipitation ended the moisture levels started into a greater than normal rate of drying losing about 0.1% moisture per day. A minimum low moisture level of 9% was reached on August 23, maintained for 4 days, then after a brief rise to 10% returned to 9% for another 10 days. For the recent severe fire danger seasons evaluated (1967, 1973, 1985, 1988) this was the second longest period of 9% or lower moisture content for any station surrounding the Scapegoat Wilderness, and the longest for a low elevation station. The seasonal average low moisture content at Lincoln is usally about 14% and occurs during late July and early August. During 1988 there would be 33 days when the Thousand Hour Fuel Moisture was 10% or less which is the longest extended period at this moisture level for any station near the wilderness. The return to more normal moisture levels in early September 1988 was more rapidly accomplished, a rise of about 1.3% per day, than occurred during other recent severe fire danger seasons in this portion of the Northern Rocky Mountains.

Late May Thousand Hour Fuel Moisture at Gleason's Resort has the highest seasonal average moisture level of about 29% (fig. 12). During this season in 1988 the moisture levels were already about 4% below normal. Typically this station indicates an increase in moisture levels during late May and early June, even during years which would later be classified as severe fire danger years. This period of increased moisture did not occur during 1988 until late June before which the large fuel moisture levels had dropped to approximately 16%, about 7% below normal. After a brief rise back to 20%, moisture levels again began to decline on July 5 at the rapid rate of about 0.3% per day. A 1988 minimum low moisture content of 11% was achieved on August 18. There would be 21 days during the 1988 season at this station with the moisture level at 11%. Only during the severe fire danger season of 1973 would this low moisture content level be reached at this site, and then only for a 3-day period. Typical seasonal low moisture content for this station is achieved during late July and is about 19%. The 1988 moisture levels would emulate the 1967 severe fire danger season in remaining well below normal throughout September and into early October.

Figure 11. Energy Release Component for the Gleason's Resort NFDRS Station, near the Lewis and Clark National Forest; Seasonal Average 1973-1987, 1967, 1973, 1985, and 1988 severe fire danger seasons.

Energy Release Component
Gleason Resort (241802)

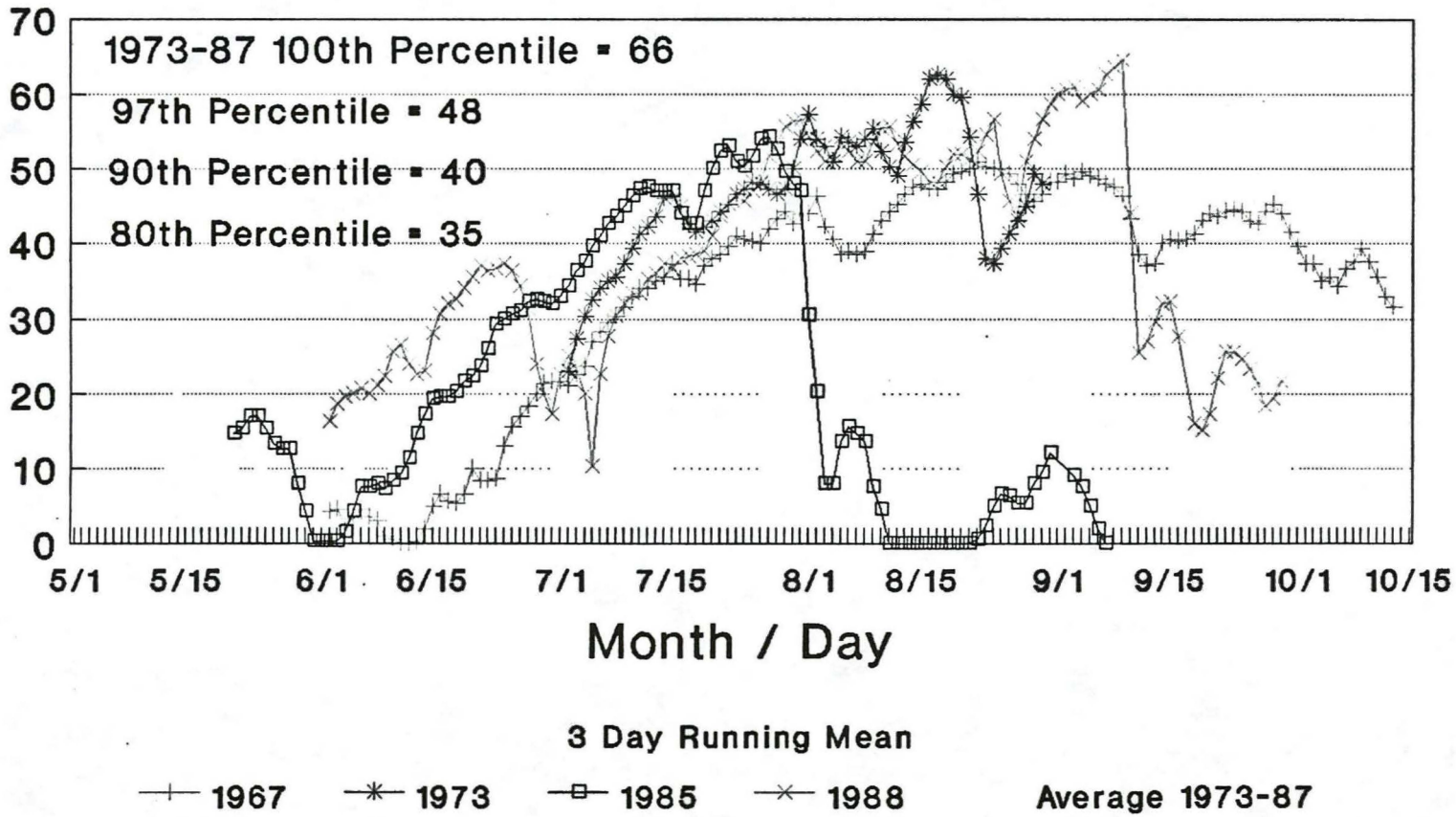

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Figure 12. Thousand Hour Fuel Moisture for the Lincoln Ranger Station, Helena National Forest; Seasonal Average 1973-1987, 1967, 1973, 1985, and 1988 severe fire danger seasons.

Thousand Hour Moisture
Lincoln Ranger Station (241904)

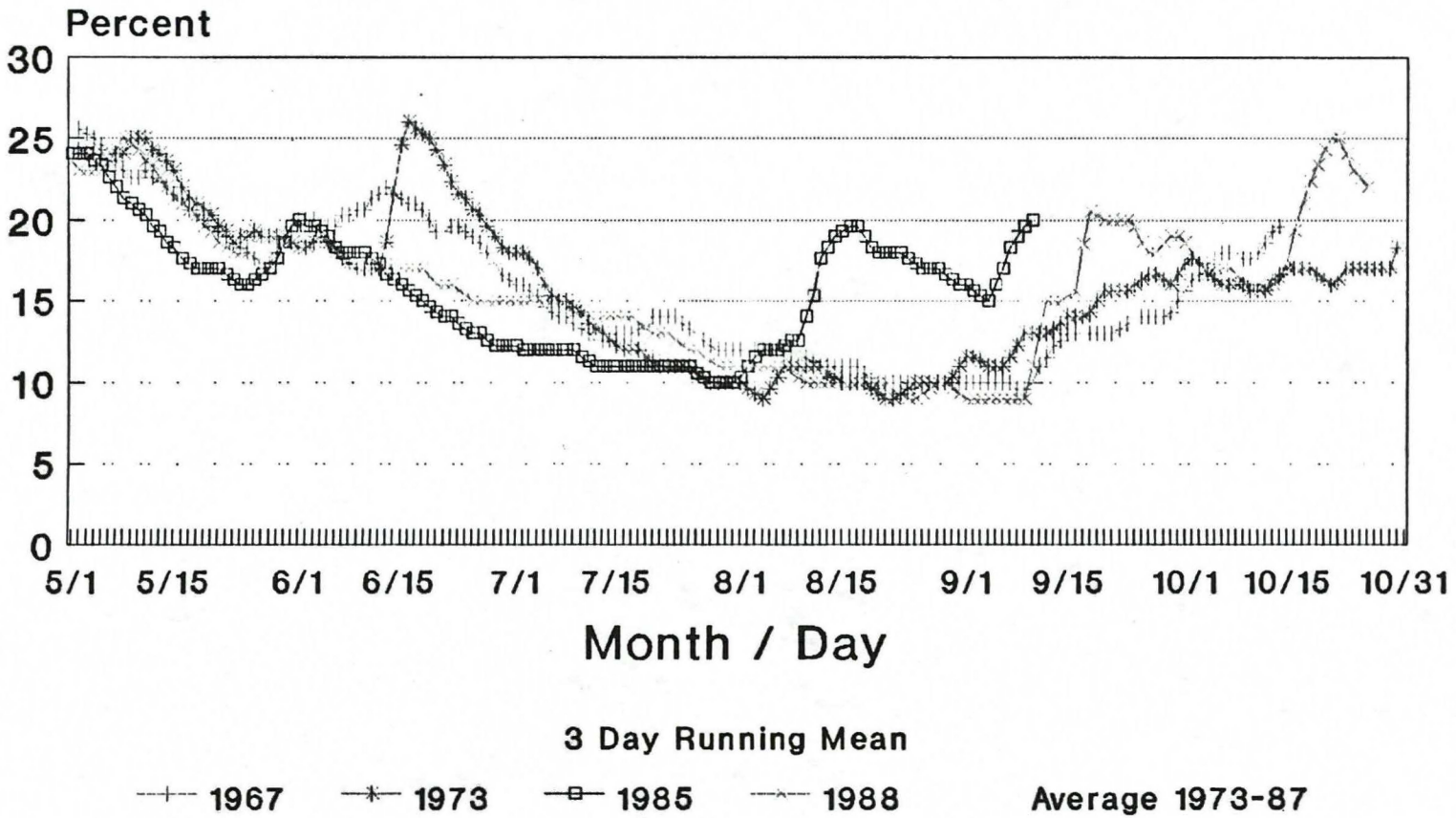

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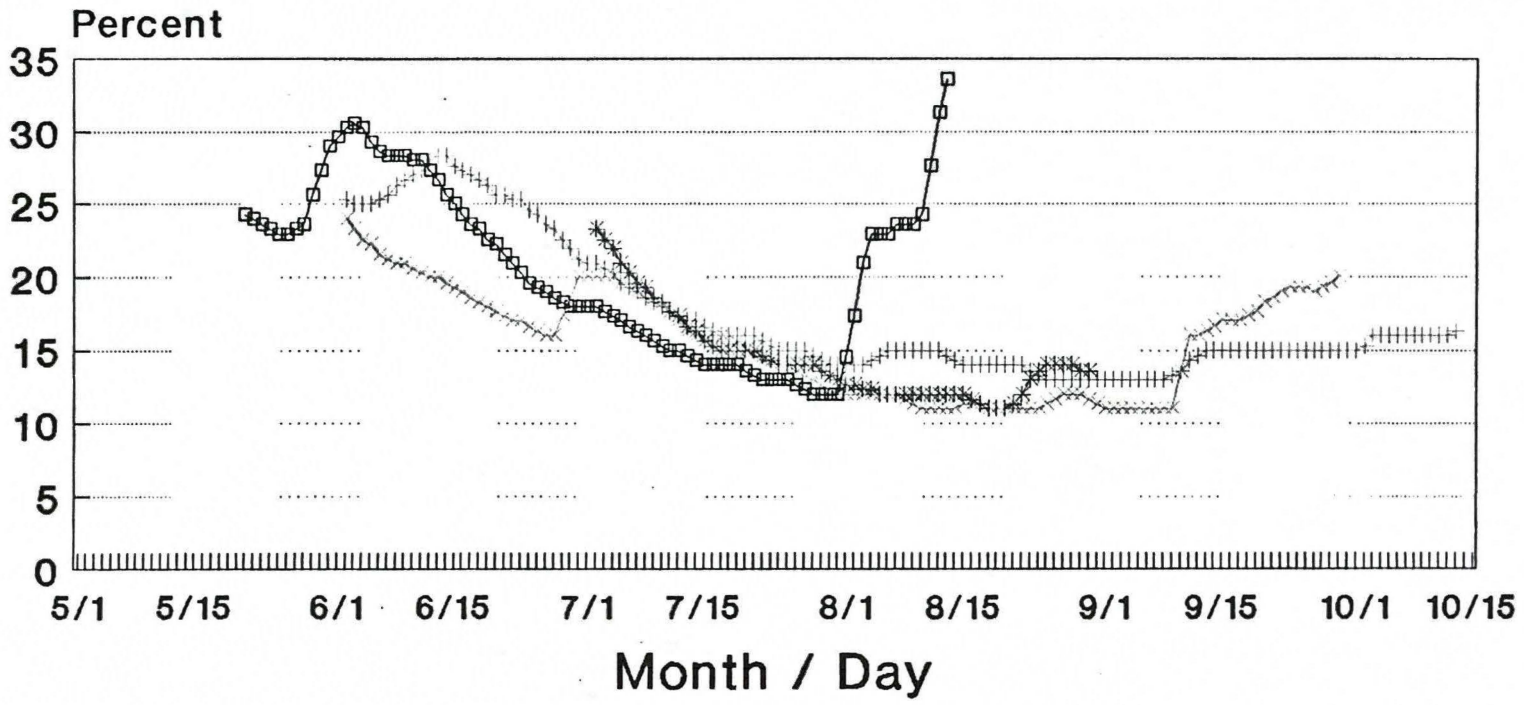
Figure 13. Thousand Hour Fuel Moisture for the Gleason's Resort NFDRS Station, near the Lewis and Clark National Forest; Seasonal Average 1973-1987, 1967, 1973, 1985, and 1988 severe fire danger seasons.

Thousand Hour Moisture
Gleason Resort (241802)



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Section 2.0 The Canyon Creek Fire

Section 2.1 Ignition and the Early Season - June 25 to July 19

On June 25, a late spring lightning storm passed over the northwestern corner of the Scapegoat Wilderness. One of the lightning strikes from this storm hit a Douglas-fir tree, scattering burning debris over an area approximately 0.3 acre in size on a northeast facing slope above the Dry Fork of the North Fork of the Blackfoot River. This tree was within a 150 year old stand of trees in which the overstory was starting to die, and which also contained a heavy accumulation of dead and down trees and young conifer reproduction (available live and dead fuel) on the ground. An hour long driving rain followed the lightning strike extinguishing the flames, but much of the ignited material from the strike continued to smolder. The Seeley Lake Ranger Station, Lolo National Forest, to the west was under the same storm and reported rain throughout the night and a 24-hour precipitation total of 0.16 inches. A group of campers led by the local outfitter, Smoke Elser, witnessed the lightning strike. To slow the fire's potential spread they gathered the smoldering debris and threw it back toward the Douglas-fir. They then dug a fireline across the top of the area of smoking debris to prevent the fire from possibly threatening their camp.

The next day Mr. Elser reported the fire when he encountered the U. S. Forest Service Wilderness Guard, Kathey Heffernen, on patrol in the wilderness. She in turn radioed the Lolo National Forest and was instructed to not put the fire out. A Complexity Level I Analysis was initiated on the new lightning-caused fire as required by the Scapegoat-Danaher Fire Management Plan (USDA Northern Region 1989). This analysis is part of the process to determine if the reported fire might qualify as a prescribed natural ignition within the wilderness. Lightning caused fires which are determined to have been ignited within a predetermined prescription, may be allowed to continue burning to help fulfill fire's natural role within the wilderness alpine and coniferous forest ecosystems. Within this Fire Management Plan the pre-fire season (prior to June 30) Energy Release Component (ERC) level of 33 (80th percentile level for 1973-1980 historical data) recommends the decision point between a Complexity Level I or Complexity Level II prescribed fire in the decision process for natural ignitions within the Blackfoot Unit of the Scapegoat Wilderness (USDA 1981). The Energy Release Component is an open ended Fire Danger Rating index that is a measure of the amount of energy a fire would release within a standardized fuel bed under a specific set of weather conditions. The higher the ERC index number the greater the fire danger. The weather and Fire Danger Rating recorded at the Lincoln Ranger Station, Helena National Forest, provides fire danger data for the decision process within the Blackfoot Unit of the Scapegoat Wilderness. On this particular day the ERC level from the Lincoln Ranger Station was 39 (3-day running mean).

The preliminary Complexity Level I Analysis was completed on June 27 (USDA Northern Region 1989), giving temporary approval for the lightning strike to burn as a natural ignition within the wilderness. Continued cloudy conditions and scattered, locally heavy rain showers prevented fire management personnel from finding the fire with aerial reconnaissance. There was considerable doubt if the fire still existed since no smoke was to be found. ERC level at Lincoln was 36.3 (3-day running mean) and falling due to the continued precipitation and higher relative humidities damping the fuel and reducing potential fire danger.

On June 28 at 1300 hrs the fire was determined to still be burning and about 0.5 acre in size. A small amount of smoke was visible when the fire was flown by aerial reconnaissance and it appeared that the fire was slowly burning upslope in the duff and dead, woody fuel. The smoke volume was reported as light with excellent dispersion. The size of the burned area was principally the result of

the scattered hot debris from the lightning struck tree and a small amount of smoldering combustion. The fire was named the Canyon Creek Fire after the nearby drainage and was declared a prescribed natural fire based on the recent analysis that included prescription criteria, USFS preparedness levels (status of the current wildfire season), social, economic and environmental conditions (USDA Northern Region 1989).

The National Weather Service's long range forecast was indicating normal moisture and normal temperatures in western Montana, slightly above normal temperatures in eastern Montana, through July. The short-term forecast was for continued wetting rains and cooler temperatures through the upcoming week. The current 3-day running mean ERC level at Lincoln had dropped to 34.3 (daily ERC was 38). A second lightning strike across the Dry Fork drainage within Cabin Creek was also discovered. This additional ignition was extinguished by further rain before a prescription analysis could be completed and most likely was a product of the same storm which ignited the Canyon Creek Fire. Both Lincoln and Seeley Lake Ranger Stations reported an additional 0.18 inches of 24 hour precipitation on this date as the rain continued.

The Incident Plan and Decision Notice documentation establishing the Canyon Creek Fire as a prescribed natural fire was signed by "Acting" Seeley Lake District Ranger Dan Bailey on June 29. Continued light, scattered rains were still occurring on this date with Lincoln reporting 0.01 inch and Seeley Lake 0.03 inch during the 24 hour period. The 3-day running mean ERC level at Lincoln rose slightly to 35.3 (daily was 32).

The continued arrival of moisture had leveled off the seasonal decline of the calculated Thousand-Hour fuel particles (woody fuel with a diameter of 3 to 8 inches and an indicator of long-term drying conditions) at 15% at the Lincoln station on June 29. This was 3.1% below the seasonal average for the date and was most similar to the Thousand-Hour fuel moisture level recorded during this period in 1967 at the Lincoln station, a year which experienced an extensive Late-type severe fire danger season in this location and an accompanying late-type severe wildfire season across northern Idaho and portions of northwestern Montana (Fischer 1969, Anderson 1968, Finklin 1985). 1988 Thousand-Hour fuel moisture at the Lincoln Station had been below the seasonal average since May 17 after an early period of warm temperatures melted off the remaining snow of the previous winter and exposed large fuel particles to an extended period of drying weather. The 1988 moisture level was 2.7% higher than measured on this date in 1985 when a Main-type severe wildfire season (Finklin 1985) prevailed over much of the Northern Region.

As indicated by the 3-day running mean ERC at Lincoln on June 29, the frontal system which had been delivering all the rain fall finally exited the Region and high pressure began to rebuild on the June 30. A very dry airmass was extended over California, Nevada, Utah, eastern Oregon and southern Idaho and was spreading to the north and east. By the next day, July 1, a stationary ridge of high pressure had become firmly established extending from New Mexico to eastern Montana bringing with it warm, dry weather conditions throughout the western United States.

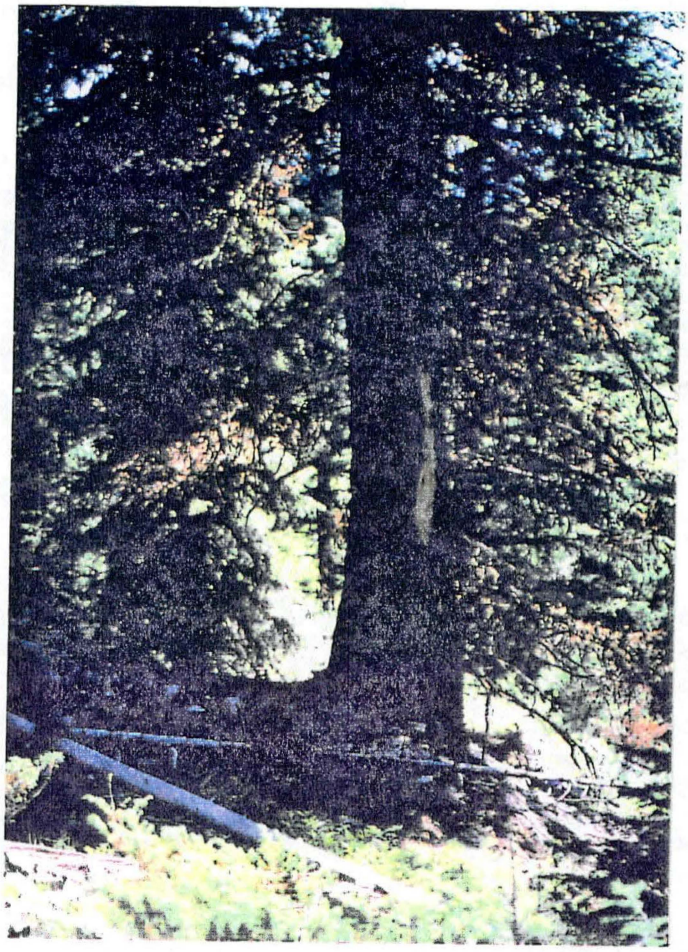
July 1 was an important date in the decision process concerning the prescribed natural fire status of the Canyon Creek Fire. The Scapegoat-Danaher Fire Management Plan requires that early season ignitions still burning after July 1 be subject to a Complexity Level Impact Analysis before continuation of the prescription status. This process for the Canyon Creek Fire was started on this date by the Lolo National Forest by bringing together an Impact Analysis Team to evaluate the present and projected burning conditions on the fire. Fires burning in the Scapegoat Wilderness are evaluated using the Lincoln Ranger Station's weather data. On this date the daily ERC level at

Lincoln was 44 (3-day running mean was 40.6) and well below 62, the maximum level recommended in the Fire Management Plan for this date. On July 12, the Impact Analysis Team presented their findings to Lolo Forest Supervisor Orville Daniels, who agreed with the team's recommendation that the fire classification continue as a prescribed natural fire.

Fire behavior during this early July period was typically smoldering in down fuel and duff with little or no visible flame. Occasionally, light smoke was visible from the trail along the Dry Fork of the North Fork of the Blackfoot River when flames of between 1 and 3 feet in length would occur during short time periods on dry afternoons when the fire reached areas of fuel accumulation. No scorching of conifer overstories was occurring during this time due to the low flame heights and general lack of heat. The fire was estimated as 1 acre in size on July 8 by the Wilderness Guard. When the fire was later observed (July 10) on the ground by Lincoln Ranger District Fire Management Officer (FMO) Byron Bonney [Bonney was also a Type 1 Fire Behavior Analyst (FBA)], the fire had spread by active smoldering only about 200 feet downslope and upslope about 40 feet (Bonney 1988). The fire around the original lighting struck tree was found to be extinguished (figs. 14-18). He measured 10-Hour Fuel (0.25 - 0.5 inch diameter pieces of wood) moisture ranging from 11% on an east aspect at the fire's origin to 16% on some north aspects above the fire. Larger rotten fuel particles were moist to the touch. Duff and soil particles also felt moist to the touch on the north aspect and in Bonney's opinion were similar to normal conditions for that time of the season; the east aspect near the fire origin was more exposed and felt a little drier. Periodic wet thunderstorms and the northern aspect of the fire site were keeping the smaller fuel particles moist and the larger particle moisture levels stable contributing to the low fire behavior observed during this time. However, the broad ridge of high pressure that had built up over the Intermountain West was now the dominant weather feature and was contributing to steadily warming temperatures and dropping afternoon relative humidities. This weather pattern caused the ERC indices at the stations surrounding the Scapegoat Wilderness to steadily rise, with the Seeley Lake Station exceeding their 80th percentile level for the first time during the season on July 8 and remaining above that level for 5 days, briefly exceeding the 90th percentile level. A Palmer Drought Severity Index issued on July 2 indicated that the majority of the Region was under extreme soil drought conditions, including the Scapegoat Wilderness, on the July 9 the index indicated worsening conditions. However, this index is designed to monitor agricultural lands and not necessarily high elevation forested lands and must be interpreted with caution on these later sites. On July 5, the Missoula Fire Weather Office of the National Weather Service issued another series of long-range weather outlooks. The 30-day outlook was, "The month of July near normal precipitation and near to a little below normal temperatures." For "July through September below normal temperatures and near to slightly above precipitation." Growing season precipitation records also issued by the National Weather Service, measurements starting on April 1, indicated that western and central Montana had received above normal amounts of moisture through July 9. East of the Canyon Creek Fire and the Continental Divide the amount of growing season precipitation received was only about half of normal. By the middle of July the growing season precipitation pattern was essentially unchanged with the central Montana area dropping to slightly below normal.

Figure 14. The lightning struck Douglas-fir at the origin of the Canyon Creek Fire on July 10, 1988. Photograph taken by Byron Bonney, USFS.

Figure 15. Light smoke rising from the area of origin of the Canyon Creek Fire from the trail across the Dry Fork of the North Fork of the Blackfoot River on July 10, 1988. Photograph taken by Byron Bonney, USFS.



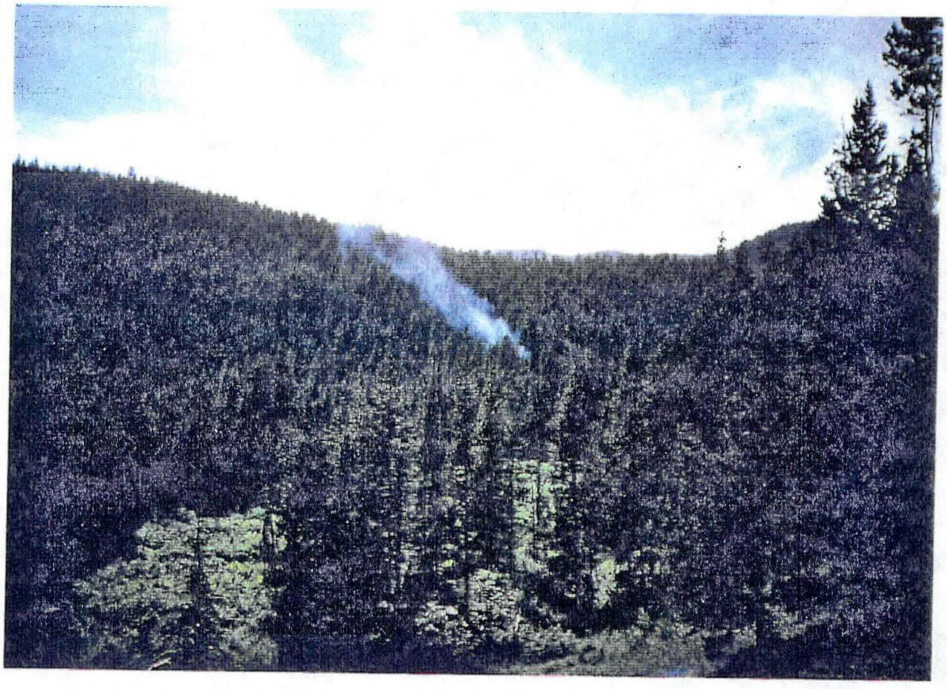


Figure 16. Location of the Canyon Creek Fire on the evening of July 9, 1988, on an east-facing slope above the Dry Fork of the North Fork of the Blackfoot River (fire location is inside the drawn circle; no smoke was evident on this aerial pass). Photograph taken by Byron Bonney, USFS.

Figure 17. The Canyon Creek Fire on July 10, 1988, smoldering and some isolated flaming in duff and dry dead and down woody fuel. Photograph taken by Byron Bonney, USFS.

Figure 18. The Canyon Creek Fire on July 10, 1988, smoldering in duff and typical dead and down woody fuel on the site. Photograph by Byron Bonney, USFS.

Section 2.2 Fire Growth Begins and Enlarges with Periodic Fire Runs—July 20 to August 8

After being semi-dormant at less than 1/2 acre for 26 days the Canyon Creek Fire became active on July 20. Pushed by local strong winds, the fire climbed for the first time into the forest canopy with occasional tree torching and some short distance spotting. Smoke was first reported by an Aerial Patrol at 1747 hrs and was observed 3 minutes later by the Silver King Lookout, located approximately 24 miles to the east-southeast of the fire origin. During this day the ERC levels at the Lincoln Station climbed above the 80th percentile level for the first time during the season, and at Seeley Lake above the 90th percentile level once more. Lincoln would remain above the 80th percentile level the rest of the summer until September 10, Seeley Lake stayed above the 90th percentile until September 9, as the long-range weather forecasts failed to materialize. The dominant ridge of blocking high pressure remained in place over the Intermountain West with warm, dry, stable air causing high temperatures in western Montana into the 90 F range. Subsiding air had also been noted during the morning at high elevation weather stations which recorded low morning relative humidities. On the next morning the increased fire behavior continued with the fire spotting to the east side of the Dry Fork. The combination of direct upslope winds and low afternoon fuel moistures on this previously unburned southwest facing aspect contributed to the fire showing its first major increase in size, growing to about 56 acres by the end of the day. Fire behavior was limited to the burning of surface fuel and the occasional torching of individual or small pockets of conifers. The fire jumped over and missed burning the riparian area along the stream between the slopes. By 1400 hrs the fire was putting up its first major convection column and smoke traveled over the Continental Divide and out over the adjacent plains.

The next morning (July 22) there were scattered spot fires still burning from the previous days fire run. By early afternoon the fire behavior consisted of creeping and torching on the perimeter flanks with torching tree top flame lengths half again the tree heights as 1-Hour Fuel (0 - 0.25 inch diameter particles) moisture levels dropped to 2% (as measured at the Monture RAWS location and estimated on site at 5900 ft msl using the BEHAVE moisture module simulation program, 2% is about as low a moisture level as 1-Hour fuel particles can reach after being dried for 24 hours in a 212 degree F oven), but winds remained light. A television camera crew brought in to view the fire from an airplane were disappointed because of the lack of more spectacular fire behavior. The camera crew had left when an active upslope and down drainage fire run commenced with an increase in late afternoon wind speeds. A large convection column was developing by 1500 hrs and the fire run was well established an hour later. By 1900 hrs only scattered areas were still burning and the convection column had collapsed. Acreage within the fire's perimeter increased to 1,060 acres on this date.

On July 23 a similar pattern of fire behavior was observed, except on a grander scale. At 1435 hrs the Silver King Lookout reported a large convection column developing on the fire (fig. 19). Strong local upslope winds, estimated to be around 50 mi/h by the Wilderness Ranger who was standing on a nearby drainage divide northwest of the fire, drove the fire up the Cabin Creek drainage toward Scapegoat Mountain. The fire run peaked about 1700 hrs and was essentially completed by 1900 hrs after traveling to the vegetated upper reaches of Evans Peak and into Dobrata Creek at the base of Scapegoat Mountain, a distance of about 6.3 miles. The wind-driven crown fire run was estimated to have a rate-of-spread of approximately 1.6 mi/h (127 chains per hour) with above crown flame lengths of about 60 feet. Maximum spotting distance during the crown fire run was calculated to be approximately 1 mile. Along the northern flank of the fire run the fire etched a sharp burned-unburned line in the tree crown at about mid-slope of the drainage with low intensity

fire slowly spreading up the slope in the ground and surface fuels. Approximately 9,322 acres were burnt on this date, resulting in about 10,326 acres in 48 hours and a convection column visible from the cities of Great Falls to the east, and Helena to the southeast (fig. 20). It was estimated at the time that only about 4,000 of the within perimeter acres were affected by the crown fire runs. With the total within perimeter acreage the Canyon Creek Fire became the largest prescribed natural fire to have burned in the entire Bob Marshall Wilderness complex since the approval of the management plans. The previous largest prescribed natural fire in the wilderness complex had been the 1985 Charlotte Peak Fire which grew to about 4,600 acres before being extinguished by rains in late July (Bushey and Goens 1985).

Fire growth remained active but was considerably reduced during the next 3 days (July 24-26) and was principally to the southeast as afternoon winds moved the fire down drainage toward the junctions of the Dry Fork, East Fork and the North Fork of the Blackfoot River (figs. 21-25). During this time period the fire traveled slightly over 4.5 miles and grew to 16,170 acres as the lower elevations of the drainage were burned out by crown fires with occasional crown fire runs up the adjacent higher side slopes of Falls Point Mountain. The fire reached the junction of the drainages on July 26 and from that point began to progress in two different directions; continued growth to the southwest up the drainage of the East Fork of the Blackfoot River and on to the Helena National Forest portion of the Scapegoat Wilderness, and to the northeast up the lower elevations of the North Fork (figs. 26-27). Only slight fire spread was experienced along the northern flank of the fire as the perimeter located in the Cabin Creek drainage burned to mid to upper slope and held at those locations due to increased fuel moisture with the changing elevation as well as a change in forest age and structure. Principal fire activity resulting in the majority of the burned acreage during this time period occurred between 1400 and 2000 hrs during which the afternoon winds increased in speed. Peak temperatures during this time were from the upper 80's to lower 90 F range, relative humidities repeatedly reached lows from 11 to 15% and 1 and 10-Hr Fuel moisture levels dropped to between 2 and 4% (measured at the Monture and Benchmark RAWS locations, and the Seeley Lake AFFIRMS station, and on site using the BEHAVE moisture module simulation program).

Figure 19. View of the Canyon Creek convection column on July 23, 1988, from the Morrel Peak Lookout (elevation 8,161 ft msl) about 19 miles west-southwest of the fire. Evans Peak (8,979 ft msl) is obscured by the smoke in this view as the fire ran up Cabin Creek west aspect and then burned around the mountain on both the north and south slopes. The Straight Creek Fire can be seen on the left hand edge of the view, also burning in the Scapegoat Wilderness but under immediate suppression action. Photograph by Janet Spencer, Montana Department of State Lands, Morrel Peak Lookout.

Figure 20. West facing aspect of Evans Peak (8,879 ft msl) after the fire run up Cabin Creek on July 23, 1988. Only isolated pockets of forested vegetation remain near the summit. Dark shadow is from the convection column forming to the south down in the Dry Fork of the North Fork of the Blackfoot River. Photograph taken July 26, 1988, by Dave Sisk, USFS.

Figure 21. Canyon Creek Fire making a crown fire run down drainage in the Dry Fork of the North Fork of the Blackfoot River, moving toward the east and the junction with the North Fork of the Blackfoot River. This view was taken on July 26, 1988, between 1330 and 1400 hrs. The canyon below the North Fork Falls can be viewed in the lower righthand corner. Photograph by Dave Sisk, USFS.

Figure 22. Spot fire adjacent to the Dry Fork of the North Fork of the Blackfoot River rapidly developing into a crown fire in Fuel Model 10. The fire was being wind-driven down canyon and to the east. Photograph was taken on July 26, 1988, between 1330 and 1400 hrs by Dave Sisk, USFS.

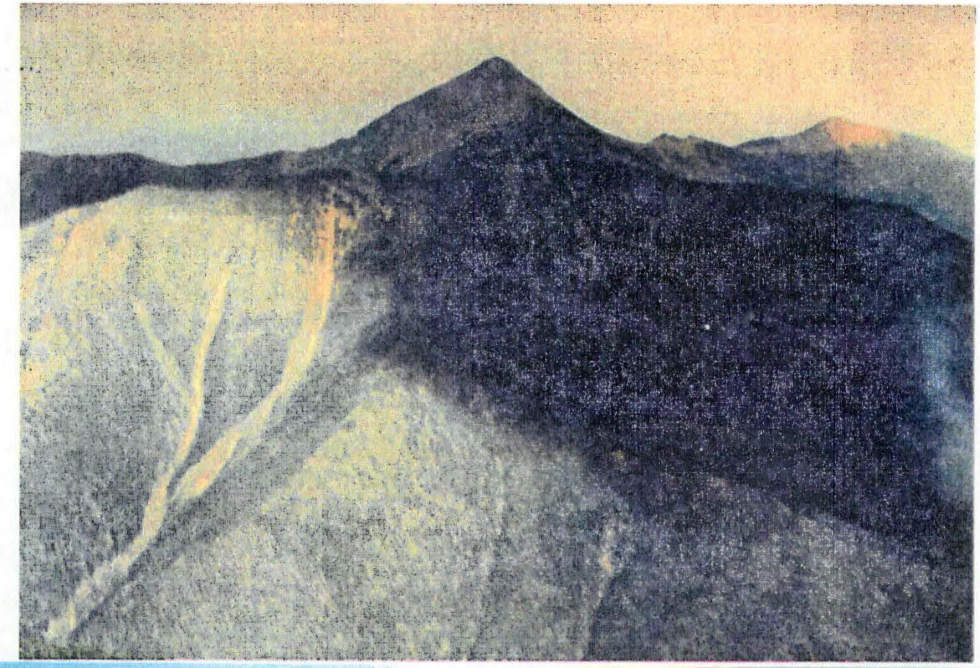


Figure 23. Canyon Creek Fire moving east along the glacial alluvial bench above the junction of the Dry Fork and the North Fork of the Blackfoot River. Fire is burning in Fuel Model 10 mixture of lodgepole pine, Douglas-fir, and spruce. The fire shelter protected North Fork Cabin is in the lower righthand corner. Photograph by Dave Sisk, USFS, July 26, 1988, approximately 1415 hrs.

Figure 24. Upslope fire runs on the north aspect of Mineral Mountain above the junction of the East Fork and the North Fork of the Blackfoot River. The Canyon Creek Fire at this point was very close to crossing the boundary between the Helena and Lolo National Forests. The fire at this time was still being driven by westerly winds. Photograph by Dave Sisk, USFS, July 26, 1988, approximately 1530 hrs.

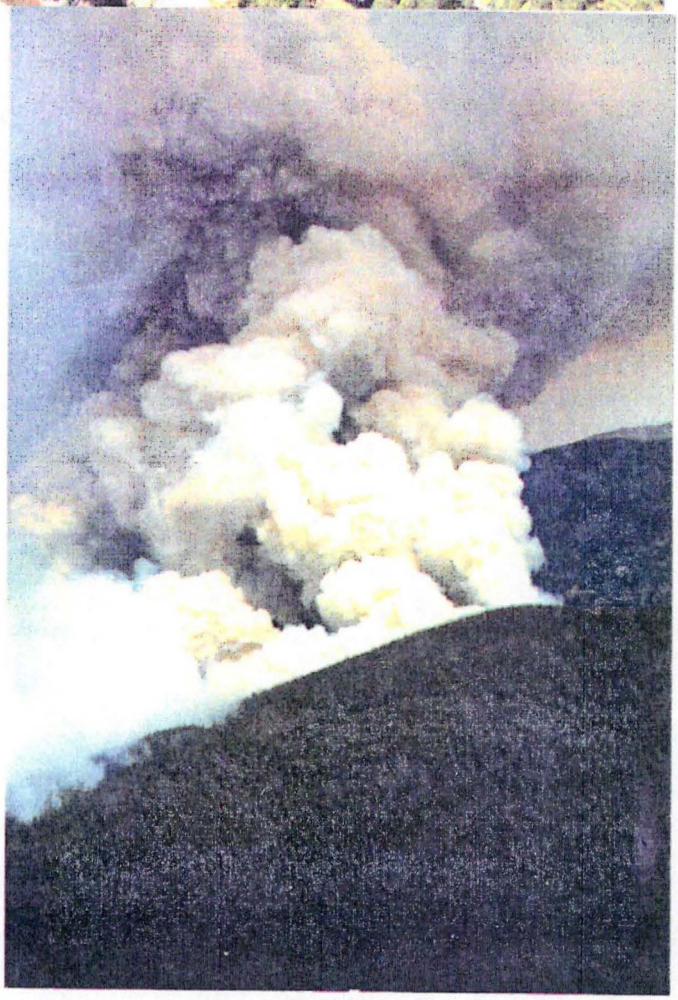


Figure 25. Convection column as viewed from the Morrel Peak Lookout (elevation 8,161 ft msl) about 21 miles west of the crown fire run at the junction of the Dry Fork and the North Fork of the Blackfoot River. This view was taken near the peak of the fire activity between approximately 1700 to 1800 hrs, July 26, 1988. Evans Peak (8,979 ft msl) appears prominently to the left of the convection column and was about 5 1/2 miles northeast of the area burning. Photograph (400 mm) by Janet Spencer, Montana Department of State Lands, Morrel Peak Lookout.

Figure 26. Area burned by the Canyon Creek Fire along the Dry Fork of the North Fork of the Blackfoot River on July 24 and 25, 1988. Principal fire spread was toward the southeast (lower righthand corner) with upslope runs on either side of the drainage. Rising smoke can still be seen from the run up Cabin Creek on July 23 in the left background. Photograph by Dave Sisk, USFS.

Figure 27. Canyon Creek Fire looking southwest from above the deserted Falls Point Lookout, north of the junction between the Dry Fork and North Fork of the Blackfoot River. Area burned on July 24 and 25, 1988, is visible including smoke in the foreground from fire which had burned to the top of the Falls Point. Photograph by Dave Sisk, USFS.

During the later portion of July and early August the fire continued to expand in a multi-directional manner. Initially, the principal direction of spread was northeast up the North Fork drainage with the fire progressing about 3.6 miles in seven days (through August 2). Most of this burning was taking place at the lower elevations within the drainage with periodic crown fire runs up the adjacent slopes. Fire spread in this direction stopped for several days after August 2 while areas within perimeter continuing to burn actively. A small amount of additional spread was observed in the southeasterly direction up the East Fork. However, this portion of the fire encountered an area burned in 1979 (Cabin Fire) and the lack of continuous fuel due to the previous fire effectively halted the forward spread. This portion of the Canyon Creek Fire was slowly burning around the old burn perimeter lacking the proper combination of fuel, topography and weather conditions necessary to resume spreading up the drainage. Between July 28 and August 5, additional fire spread was initiated in a south-southwesterly direction up the northeast aspect of Lake Mountain. This area of new perimeter grew out of areas that burned initially on July 23 and 24 as the fire moved down the Dry Fork. Much of the spread in this new direction was accomplished through the burning of ground and surface fuels with occasional short upslope crown fire runs and considerable tree torching and spotting.

Although the Canyon Creek Fire was still in prescription, control efforts were ongoing in order to protect the fire management area's boundary. A large portion of the acreage burned on Lake Mountain on August 5 resulted from a burnout operation completed during the afternoon with the aid of upslope winds and areas of downslope rocky scree. This fire management operation was an attempt to block spread in a southeasterly direction, back across the North Fork of the Blackfoot River. The north and western portions of the fire's perimeter continued to smolder but did not contribute to any increased burned acreage during this period. Total within perimeter acreage of the fire by the end of the burning period on August 5 had gradually increased to 24,405 acres.

Environmental conditions in the Scapegoat Wilderness continued to dry as the ridge of high pressure continued to dominate the weather pattern. Afternoon temperatures remained in the 80 to 90 F range under sunny skies. By August 6 the 1000-Hr Fuel moisture measurements at the Lincoln Station had declined to 11%. Measurements collected near the summit of Lake Mountain showed even lower moisture in 3- to 4-inch diameter fuel particles, 7.5% at about 8,200 feet msl elevation and between 5 and 7% at 7,000 feet msl. Moisture levels approaching 9% in the 1000-Hr Fuel is generally considered indicative of a prolonged drought situation in the northern Rocky Mountains (Bradshaw *et al.* 1983). On August 6, a 3-week period of no rain was briefly broken as a band of showers developed along a Pacific frontal system moving through western Montana. Light rains were reported from Kalispell to Seeley Lake and along the west slopes of the Rocky Mountains, elsewhere including the Canyon Creek Fire only clouds and slightly higher afternoon relative humidities and cooler temperatures were experienced. A weak rebound of the high pressure ridge quickly followed the frontal passage returning the fire vicinity to sunny skies with gusty winds on August 7 and 8. On August 9, the Lincoln Station ERC level moved above the 90th percentile (56.0) for the first time during the 1988 wildfire season, as a weak upper level disturbance moved through southern portions of British Columbia and Alberta causing strong, gusty winds in western Montana during the afternoon.

Section 2.3 Canyon Creek Fire Crosses the Continental Divide - August 9 to September 5

Most afternoon temperatures in western Montana on August 9 had returned to the 80 to 90 F range with relative humidities back down into the teens. As the upper level disturbance moved

through, winds gusted to 30 to 40 mi/h in many locations. Fire behavior began to pickup on the Canyon Creek Fire in the vicinity of the fire front in the North Fork drainage about 1430 hrs (figs. 28-31). By 1445 hrs the Silver King Lookout reported that the fire was "burning hot today." Between 1500-1530 hrs cold but charred debris up to 3 inches in diameter were falling around the Carmichael Guard Station at the junction of the North Fork and Cooney Creek. The fire at this time was burning in the Blackfoot River drainage and on adjacent slopes about 3 miles south of the Guard Station. The convection column was estimated by an aerial patrol at 1531 hrs to be 20,000 feet in height and continued to grow as the fire grew in intensity. Fire spread was to the east and northeast and was hooking around slopes and up timbered drainages such as Theodore Creek. Fire behavior and environmental conditions were observed by Dave Sisk, Seeley Lake FMO (and Type 1 qualified FBA), first on the ground at the Carmichael Guard Station and later by helicopter near the fire. A 40 mi/h wind was being created by the fire, while free air winds in the area were approximately 23 to 29 mi/h. Spot fires were being started up to 0.25 mile in front of the fire front, but most spot fires were starting within 0.16 of a mile. The crown fire moved rapidly up the Tobacco Valley and hit the Continental Divide about 1900 hrs throwing burning fire brands an estimated 0.5 mile into the heads of Bald Bear Creek and Upper Twin Creek east of the divide. These spot fires smoldered with only limited creeping of the flames as the day's burning period came to an end. The crown fire run up Tobacco Valley traveled approximately 5.5 miles between 1530 and 1900 hrs, averaging a rate-of-spread of 1.57 mi/h (126 chains per hour) as the fire moved through the lodgepole pine canopy in the lower elevations and subalpine forest on the higher adjacent slopes. The wind driven fire run had calculated flame lengths of 40 to 60 feet above the tree canopy (crown fire behavior calculations based on Rothermel, 1991). In most cases the fire closely followed the main drainage, burning to the adjacent ridge tops and just crossing the lower mouths of drainages feeding into the Tobacco Valley and the upper reaches of the North Fork of the Blackfoot River. The within fire perimeter acreage grew on this date by 7,743 acres, all in the vicinity of the Tobacco Valley, to a total of 32,148 acres.

Figure 28. Early growth stage of the convection column of the Canyon Creek Fire as it approached Tobacco Valley (August 9, 1988; approximately 1500 hrs). Fire at this point is moving up the North Fork of the Blackfoot River drainage in a northeast direction. Olson Peak (8,881 ft msl) rises its rocky, bare slopes right of lower center. Photograph by John Wilson, USFS; from the Silver King Lookout, Helena National Forest.

Figure 29. The Canyon Creek Fire convection column at the approximate time the fire began its easterly run up Tobacco Valley (August 9, 1988; approximately 1530 hrs). The fire at this point was burning in a mosaic of Fuel Models 10 and 9, with the model 10 providing the ladder fuel into the crowns of the pockets of model 9. Height of the convection column was estimated to be about 20,000 ft at this stage. The three peaks in the center of the view are from left to right; Galusha Peak (8,506 ft msl), Olson Peak (8,881 ft msl), and Pyramid Peak (8,688 ft msl). Photograph by John Wilson, USFS; from the Silver King Lookout, Helena National Forest.

Figure 30. Crown fire run in Tobacco Valley is well engaged by the Canyon Creek Fire (approximately 1745 hrs). The valley bottom and midslope elevations of the adjacent elevations were Fuel Model 9 (Fire Group 7) with Fuel Model 10 (Fire Groups 6, and 8) and areas of Fuel Model 1 (Fire Group 10) on ridges above the valley. Photograph by John Wilson, USFS; Silver King Lookout, Helena National Forest.

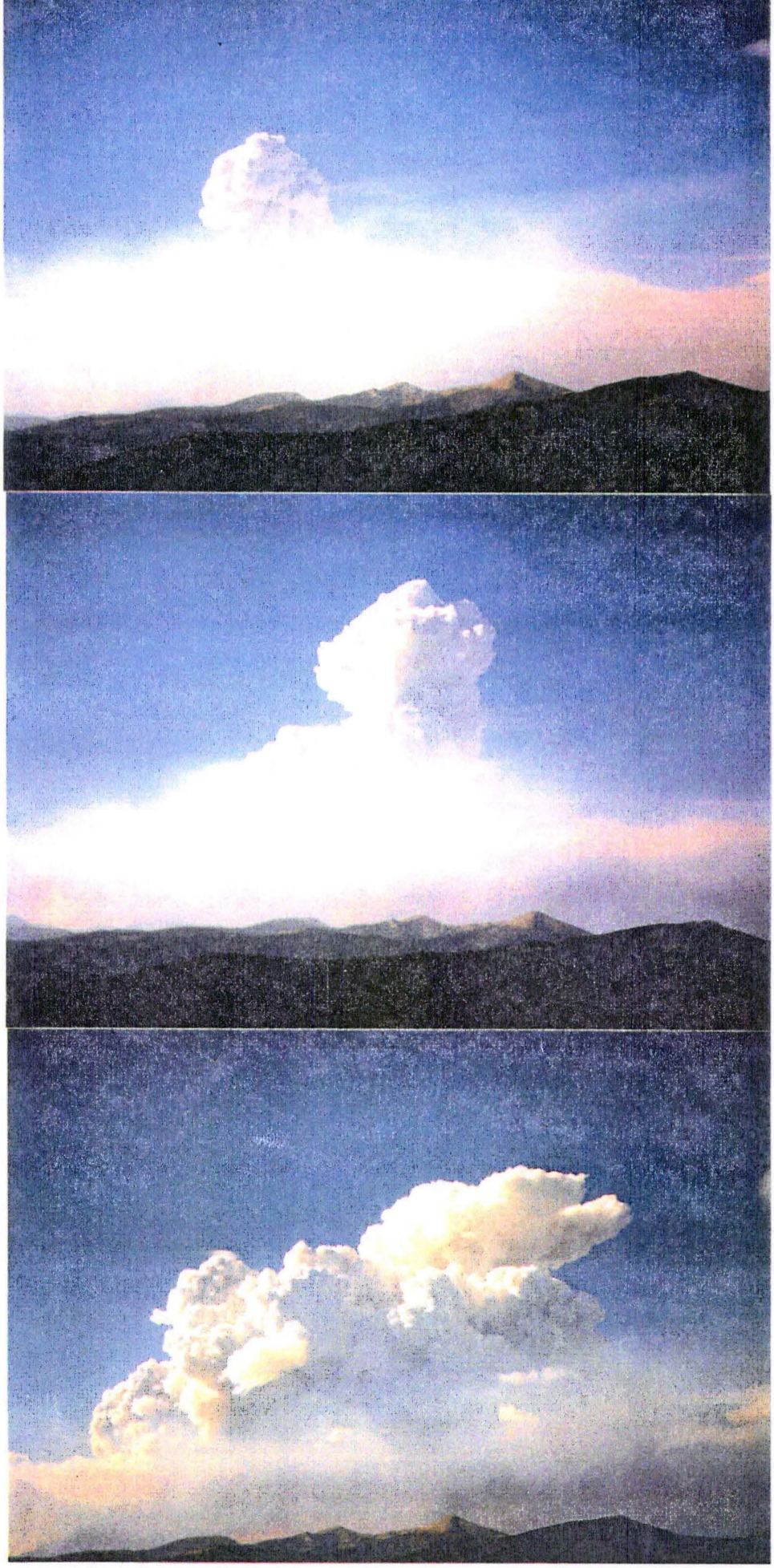
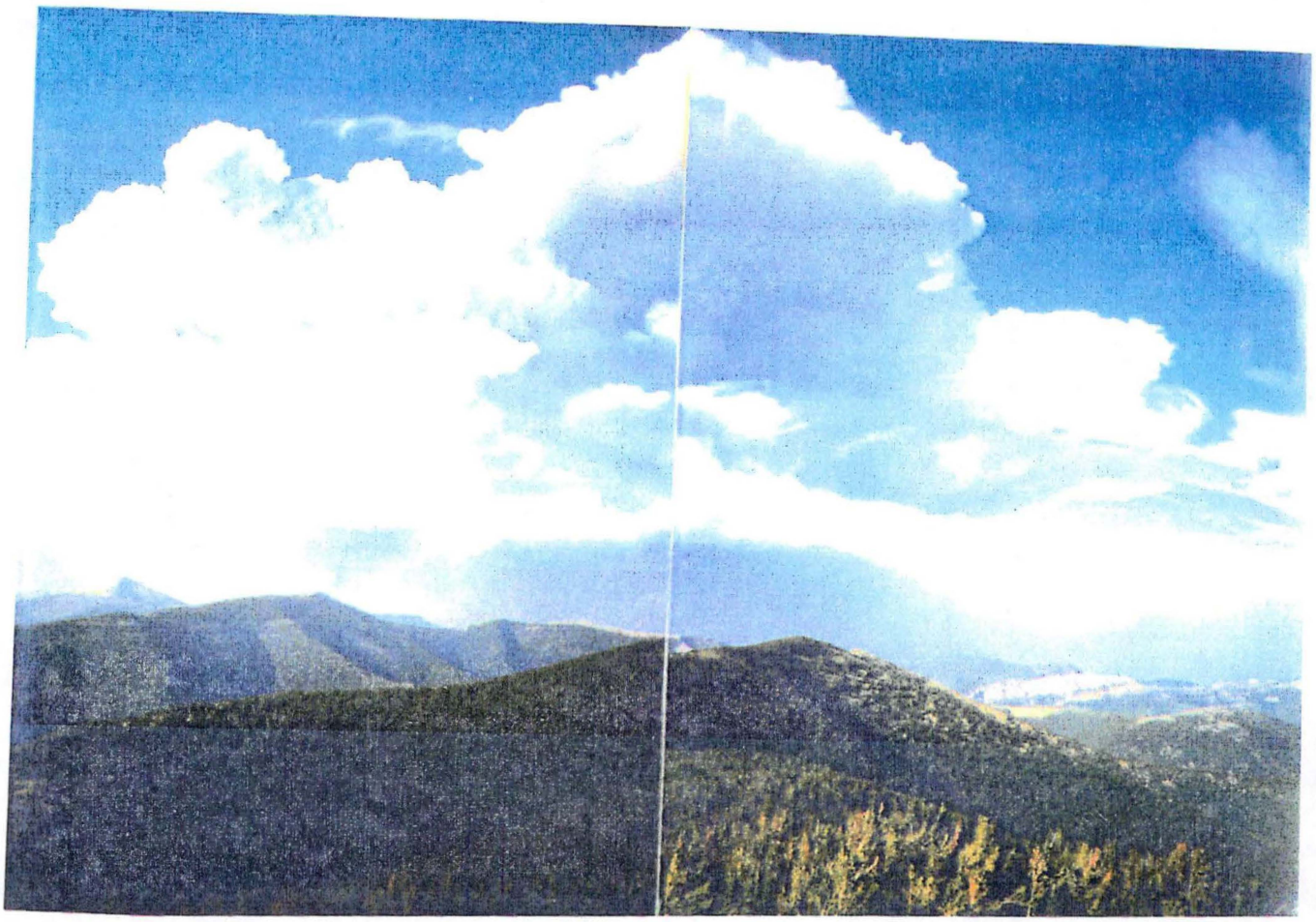


Figure 31. Canyon Creek Fire has run the length of Tobacco Valley and encountered the slopes of the Continental Divide (August 9, 1988; approximately 1900 hrs). Spot fires were thrown up to 1/2 mile on the east side of the divide. Pyramid Peak occupies the left side of the view and is about 3.6 miles southeast of the fire run. Composite photographs by John Wilson, Silver King Lookout, Helena National Forest.



Following this short period of explosive growth the Canyon Creek Fire became relatively inactive in its perimeter growth. During the next 10 days (August 10 through 19) the fire continued to burn within the perimeter with Fire Lookouts recording afternoon comments such as: "Mushroom cloud in the Scapegoat...as usual." Even the spot fires begun by fire brands across the Continental Divide on to the Lewis and Clark National Forest's portion of the wilderness, by the Tobacco Valley run, were restricted to 200 acres. These spot fires were being fought by a Tactical Team that started blasting fireline to prepare for burnout operations in an effort to protect the fire management area boundary. Water drops were also being used to help cool down the spot fires. It was the weather, however, that was the principal cause of the mild fire activity. On August 11, a weak Canadian cold front brought cooler temperatures and higher relative humidities. The front also produced scattered thunder storms which started new fires, several in the Scapegoat Wilderness, which were actively suppressed. The change in weather slowed the climb in fire danger but did not halt it. On August 14, the Lincoln Ranger Station again exceeded the 90th percentile ERC level, and would remain above this statistical marker until September 10. Throughout most of the period the afternoon high temperatures in the vicinity of the fire reached into the upper 70's, relative humidities only attained lows between 20 and 30% with night time humidity recovery from 70 to 100%. A southwest air flow following the frontal passage producing scattered, light rain showers throughout western Montana.

On August 19, as the Fire Danger continued to increase (Lincoln's ERC level was now above the 97th percentile level), afternoon winds increased and humidity levels east of the Continental Divide dropped below 10% preceding a dry-cold front approaching from British Columbia. At about 1400 hrs a wind driven crown fire developed from the spot fires which the Tactical Team had been working on, east of the Continental Divide. This fire moved to the northeast covering 673 acres as it burned along the ridge between Bald Bear Creek and Lost Cabin Creek and then down slope toward the Dearborn River drainage. After spreading for about 3 hours, fire activity decreased and the fire did not cross the Dearborn River as feared. While this fire run was not as large as those which had occurred during the earlier life of the Canyon Creek Fire it would signify a new phase of the fire; active down drainage burning on the east side of the Continental Divide (east zone) into areas which had received significantly less amounts of precipitation during the year than areas near the fire's origin west of the divide (west zone). If as expected, the fire crossed the narrow Dearborn River, the fire would encounter very little in the form of naturally occurring fuel breaks that could hinder fire spread.

Winds during the night from the passing cold front kept some fire actively burning within the perimeter of the new fire run. During the next day, August 20, the containment effort was remobilized to hold fire west of the Dearborn River. Five spot fires were found on the east side of the Dearborn and actively suppressed in the morning to prevent escape when the afternoon southwest winds arrived. Crews also burned out fuels between the river and the fire.

As a high pressure ridge rebuilt over the region over the next several days the afternoon relative humidities gradually dropped and temperatures warmed. Initially, the crews working the Dearborn River area experienced little problem in containing the fire. But with each day the fire behavior intensified. On August 22, as temperatures rose above 70 F, relative humidities dropped below 20% and afternoon winds started to increase, the fire in this area again threw a spot fire across the river. This spot was quickly lined, but the incident was indicative of fire behavior and weather conditions to come. Efforts were being concentrated with the limited fire suppression resources available on the area of fire near the Dearborn River. Fire behavior was also increasing in other areas, especially back near the Continental Divide where the Canyon Creek Fire had initially spotted across and

along the northeast facing slope above Bald Bear Creek, these areas were under observation but not active suppression. Spot fires were also observed in numerous other locations around the fire's entire perimeter, but most fire activity continued by burning within the fire perimeter. One of these areas was on the northwest side of the ridge on top of Lake Mountain were spot fires had started on August 5. These spots had been smoldering and occasionally torching small groups of subalpine fir and Engelmann spruce. This activity created more embers and spot fires and slowly expanded the extent of burning. On August 23, a subsidence inversion developed within the ridge of high pressure and started to contribute to drying high elevation fuel conditions over a large geographic area and restricting the night time moisture recovery in the fuel (Bushey 1989). During the afternoon of August 24 as temperatures rose into the upper 80 F range and relative humidities dropped into the low teens, torching and spotting increased in many areas. Along the ridge above Bald Bear Creek the fire again made a run toward the Dearborn River, then hooked down the Dearborn toward the south and upslope into the adjacent drainage still west of the river. Another spot fire started by a fire brand thrown east of the river grew to 10 acres before it was contained. Mapping later revealed that 533 acres burned on this date, increasing the total within perimeter acreage to 33,478 acres. During the night the fire came under the influence of an east wind which aided suppression actions on fire east of the Continental Divide, but caused problems on the western fire perimeter.

On August 25, as the warm, dry conditions with an east wind persisted, the spot fires on Lake Mountain in the western zone had grown to about 100 acres on the northeast face of the mountain. By 0800 hrs the fire in this area was actively torching trees in the upper end of the East Fork of Lake Creek. The fire became very active early and began to spread by 1000 to 1100 hrs. By 1400 hrs the fire intensity was too high for any form of manual suppression action. Additional fire spread was also noted on the south flank of Lake Mountain as the fire backed down toward the Madison Creek drainage. Numerous other areas along the fire's perimeter west of the Continental Divide that had been inactive for extended periods of time became active on this day and the fire grew an additional 3,692 acres to a total of 37,160 acres. These areas of active perimeter burning would commonly back into the wind until the fire was favorably aligned with the wind resulting in a short upslope run that greatly increased the active flaming front. Higher humidities and the east wind on this date helped keep the fire activity on the east side of the Continental Divide down to a minimum as mop-up continued on the previous afternoon's fire run.

Similar environmental conditions continued on August 26, resulting in additional burned acreage west of the Continental Divide. The fire south of Lake Mountain continued to burn actively, backing a quarter of the distance toward Madison Creek. This fire was backing with an average flame length of approximately 3 feet, torching subalpine fir and pockets of heavier fuel as they were encountered which burned intensely. Areas with fuel discontinuity created a mosaic of unburned fuel and vegetation as the fire backed through. The creeping persistent nature of the fire spread did cause some of these unburned areas behind the main backing fire to eventually burn, as did spot fires from firebrands created by the torching trees. It was thought that this part of the fire could be held at midslope on Lake Mountain and kept from moving outside the wilderness boundary on the other side of Lake Creek or across the North Fork of the Blackfoot canyon. Priority for the containment action was placed on keeping the fire in this area west of the Blackfoot River. East of the divide; the east winds, high relative humidity, and a 0.25 inch rainfall from a passing thunderstorm over much of the fire in the east zone helped the crews progress in fire mop-up. After this rainfall, much of the perimeter in the east zone looked, from the air, as if the fire had been extinguished. Only a few very isolated areas were putting up small amounts of smoke. However, this appearance was deceiving as the fire remained smoldering and hot beneath tree canopies and logs that escaped the rain. From the air the eastern perimeter looked "cold" but was actually very

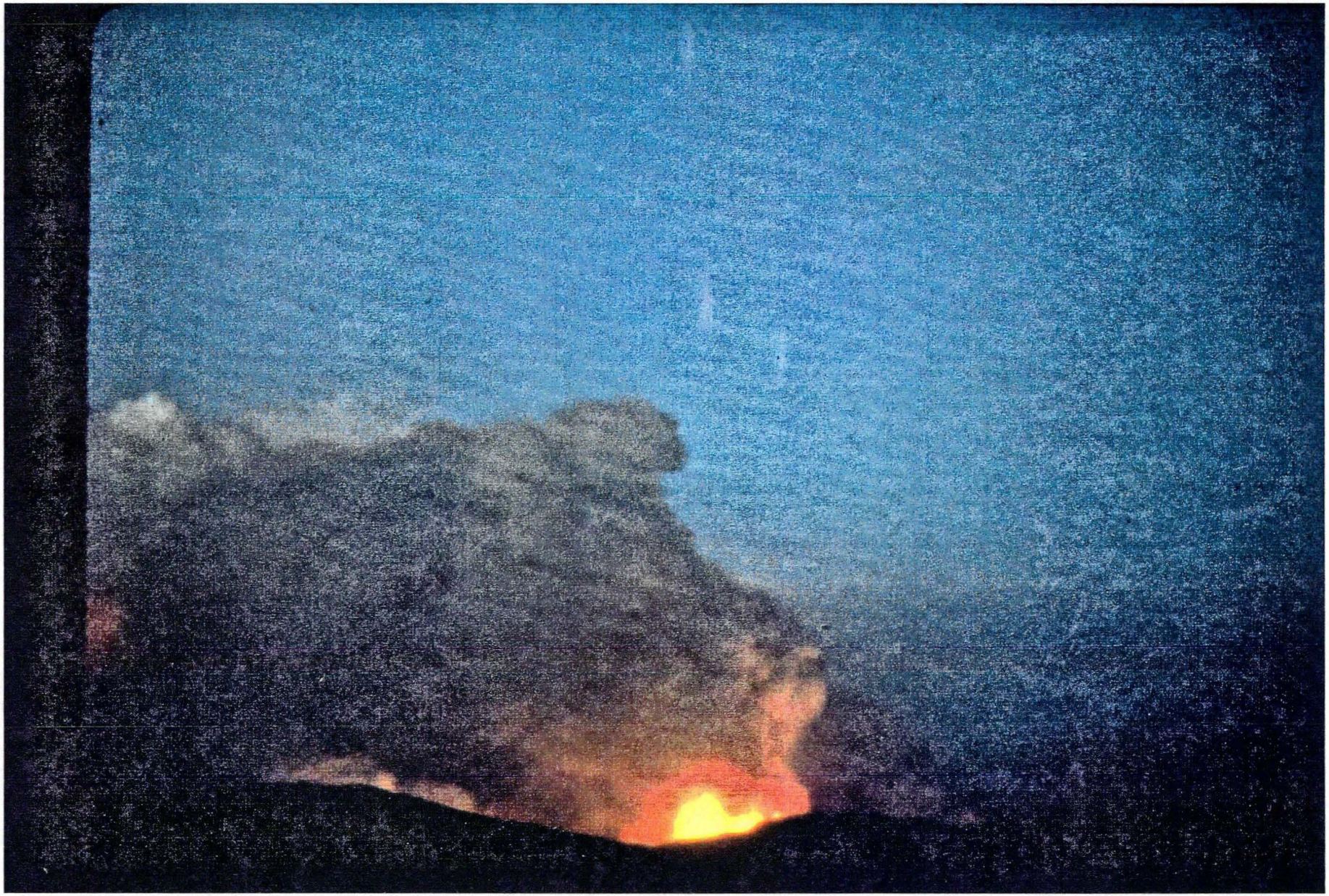
"hot." The right weather conditions and drying of the more exposed fuel would cause the fire to again resume its forward spread.

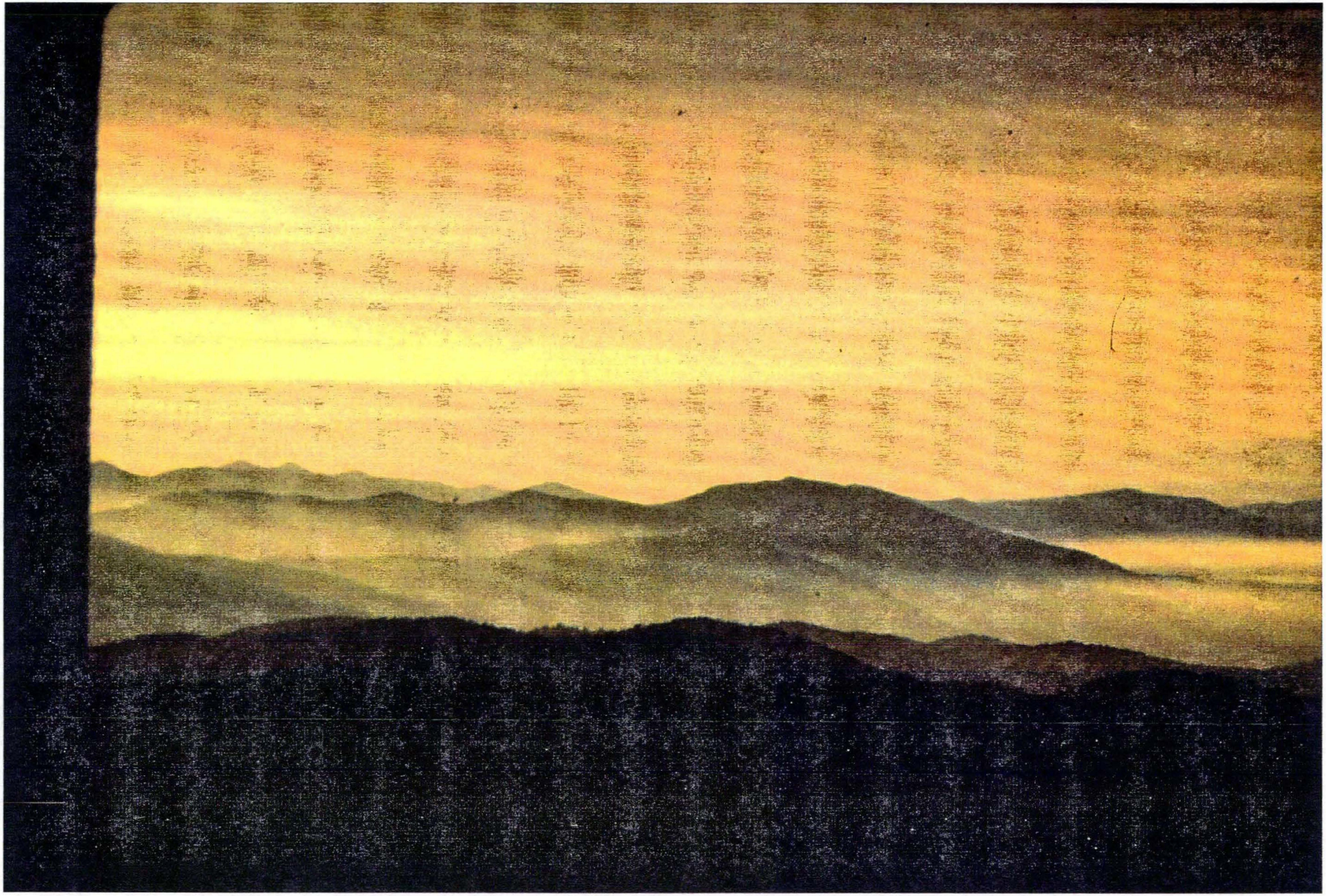
Even though there had been fire in the East Fork drainage of the Blackfoot River for the past month; remaining from the the fire run through the junction of the Dry, East and North Forks of the Blackfoot River, activity in this area had remained low. The broken and discontinuous fuel caused by the topography and the old Cabin Fire had hindered the formation of a fire front. During the afternoon of August 27 fire in this area finally burned through a saddle 2.5 miles north of Mineral Hill and started backing downslope to the south into Mineral Creek, then made hooking runs upslope (Bonney 1988) under the influence of both east winds and convective afternoon winds. This opened a completely new area of available fuel with the eventual return of prevailing west and southwest winds as well as down drainage winds. Fire on the west flank of Lake Mountain also continued to burn downslope to the northwest under the influence of continuing east winds. Burned acreage increased to a total of 38,026 acres.

Little fire behavior was reported on August 28 as a strong ridge of high pressure aloft continued to be the dominant weather feature. The surface pattern over the area was very flat and the flow aloft was now southerly and quite weak. Most mountain valleys were experiencing moderate temperature inversions during the morning and smoke was pooling beneath the inversions several hundred feet in depth. These usually broke between 1100 and 1200 hrs with the development of convective breezes, the exposed sites broke earlier (0930 to 1000 hrs). Subsidence inversion had become reestablished over the northern Rocky Mountains. This subsidence inversion became lower in elevation during the night thus accelerating drying of fuel and preventing night time humidity recovery. Temperature inversions were creating thermal belt conditions which promoted night time burning conditions. As a result, fuel moisture recovery on the night of August 28 and the following morning was very poor.

As the smoke trapped by the temperature inversion lifted at approximately 1200 hrs on August 29, fire in the middle of Lost Cabin Creek on the east side of the Continental Divide began to flare up and burn downslope toward the Dearborn River. Within an hour it was also starting to run near the mouth of the same drainage. Under the influence of increasingly gusty up drainage and upslope winds, trees began to torch on the north side of the mouth of the drainage. Fire further up stream in Lost Cabin Creek started to move to the northwest under stronger upslope winds. Moving in these two directions the fire eventually spotted across the Dearborn River at 1523 hrs, as well as continue to burn up drainage toward the ridge separating Lost Cabin and Cave Creeks.

The spot across the Dearborn River quickly burned a narrow 12- to 15-foot strip up the slope toward the wilderness boundary located at the ridgetop above the east side of the river. Once the fire reached the ridgetop it crossed previously blasted fireline built to contain this possible fire behavior. The slope and ridgetop was an area of scattered conifers with a heavy grass fuel understory. The fire spread rapidly along the ridgetop then downslope driven by the prevailing winds along relatively gentle terrain into heavier conifer fuel within the Jakie Creek and Weasel Creek drainages. By 1830 hrs the fire had spread between 0.25 and 0.5 mile into the heavy, down fuel at the head of the two drainages. Fire behavior was mostly a surface fire with considerable torching that spread down the two principal drainages, then made runs back up adjoining drainages. During the night a weak upper trough of low pressure passed over the northern Rocky Mountains causing gusty winds. By 2400 hrs the wind started to pick up from the west and the fire east of the Dearborn was reported to be burning intensely with flame lengths up to 200 feet and spotting 0.25 to 0.5 mile with west to southwest winds 30-35 mi/h. Driven by these night time winds the





fire moved on to non-wilderness lands managed by the Lewis and Clark National Forest.

While the fire was making its run toward and beyond the wilderness boundary to the northeast, the fire was also continuing to burn actively up Lost Cabin Creek and adjacent side drainages toward the northwest. The fire spread in Lost Cabin Creek was characterized as a slow moving crown fire, spreading by radiant heat through the tree crowns against the slope and prevailing general winds. Both fire areas on either side of the Dearborn River burned throughout the night as fuel moisture recovery east of the divide remained poor. Fire activity on this date west of the divide was restricted to burning within fire perimeters with some backing activity on Lake Mountain. Approximately 7,824 acres were burnt on this date bringing the within fire perimeter total to 46,172 acres.

By 0800 hrs on August 30 the fire east of the Dearborn River was in the drainages of Jakie Creek, Weasel Creek, Elk Pass, Bunchgrass Creek and Horse Mountain. At 0510 hrs the entire burn area was declared a wildfire. As the fire continued downslope the terrain became increasingly rough with extensive areas of mineral soil and fuel discontinuity. The fire became scattered in the many different drainages with no particular fire front. During the day fireline was constructed up Sawmill Gulch and past Blubber Creek. As the winds continued from the southwest to northwest the fire made some crown fire runs within the fire perimeter but had stopped making any strong advances. Fire crews began burnout operations in rough fescue grasslands that produced 10- to 12-foot flame lengths and very rapid spread as the fire burned upslope into the wind. As fire from the burnout operations carried into adjacent lodgepole pine stands with open understories, the fire spread became spotty and fire behavior was reduced to creeping through the duff. The fire would not carry into the forest canopy. By the end of the day an estimated 7,000 acres of non-wilderness lands and 80 acres of private land had burned on this portion of the fire.

After burning all night on the west side of the Dearborn River the fire had spread into the upper portions of Lost Cabin Creek and the head of the Dearborn River. At about 1200 hrs the fire was still spreading northwest on a line approximately half way downslope on the northwest facing aspect of the Dearborn drainage about 1.5 miles into the Cave Creek drainage.

West of the Continental Divide the fire in the Madison Creek and Lake Creek trails areas continued to back into the wind at less than 66 feet per hour. Some torching of sapling sized trees by radiant heat in advance of the flaming front was occurring along with torching of 60% to 80% of pole sized trees by convective heating as the flaming front backed beneath the trees. Control problems were being experienced by the fire crews due to the dryness of the fuel and the intensity of the fire (Carlson 1988). Fire in this area had spread down Lake Mountain and into the Madison Creek drainage about half way down the south slope. On the east side of Lake Mountain the fire was on the edge of the North Fork but still west of the river. Extreme burning conditions were experienced on this date in the western zone of the fire where afternoon temperatures rose to 80-85 F, relative humidities dropped down to 15% to 25% and southwest winds were 10-15 mi/h (Carlson 1988). By the end of August 30th an additional 7,667 acres had burned on both sides of the Continental Divide for nearly 15,500 acres during the previous 48 hours. The Canyon Creek Fire had grown to 53,840 acres within the perimeter.

As August came to an end the National Weather Service was calling for a continuation of the hot and dry conditions being experienced as the high pressure was predicted to persist with clear skies. The forecast for the next 10 days was for temperatures much above normal and no precipitation. Normal high temperatures at this time of the year are in the 70's F range. Very different from the

upper 80 to low 90 F range that were occurring. Low relative humidities typically were in the low teens, and 1 and 10-hr Fuel moistures were dropping day after day to 3-5% and 6-10% respectively. These were exceptionally good burning conditions, and if winds developed the fire behavior would increase significantly. Subsidence inversion at the higher elevations was still contributing to the drying of high mountain fuel (Bushey 1989).

On August 31, the winds remained light and fire behavior was subdued compared to previous days. In the Madison Creek area the fire continued to back into the wind at the same intensity as the day previous. More active fire behavior was taking place in a basin on Lake Mountain containing the East Fork of Lake Creek and along the upper ridge above the Canyon Creek Fire's point of origin. In both cases the fire behavior consisted of very active backing fire (Carlson 1988). On the east zone of the fire, burnout operations continued in the Blubber Creek drainage with upslope easterly winds. Compared to recent days the 500 acres burned on this date was a small amount, raising the within perimeter total to 54,340 acres.

On September 1 the weather situation became even more ominous as the ridge of high pressure continued to build in the Intermountain West with its axis along the west coast bringing warm, dry, stable air with light winds over the Canyon Creek Fire. A thermal low pressure area was developing over California and Oregon producing extremely warm temperatures along the coast, and a surface high pressure system was building over eastern Montana. These factors contributed to the establishment of an easterly airflow over the fire area (Goens 1990). Strong subsidence inversion conditions were developing across the mountains and were expected to worsen as the high pressure ridge drifted east of the fire. These worsening conditions were not immediately reflected in an increase in burned acreage. All of the increase on this date was on the western zone of the fire where an additional 1,126 acres were burned as convective winds extended the perimeter. East winds on the east zone contributed to burnout within the perimeter in areas of Lost Cabin Creek and Welcome Creek, areas that had burned initially on August 29 and 30.

In the western zone on September 1, a spot fire was discovered on the ridge between Madison Creek and the North Fork of the Blackfoot River. During the night, driven by down canyon winds, the spot fire backed into the river trail along the Blackfoot River. At 0930 hrs a shift in wind direction to up canyon (southwest) started to move the fire in this area up river toward the packbridge crossing the river. Rate-of-spread averaged about 590 feet per hour (9 chains/hr) with frequent torching of conifers. Also, at this time the fire started backing sporadically on the sidehill to the south along the east side of the ridge were the spot had made its initial run threatening the control line. A control line in Madison Creek prevented additional spread in that direction (Carslon 1988). Water drops on the run up the river helped to prevent the fire from spreading to the east side of the North Fork. During the night the subsidence inversion dropped down to between 4,000 - 6,000 feet msl contributing to active night time fire activity in all areas of the fire (Bushey 1989).

During the early morning hours of September 2, fire activity was low beneath the blanket layer of smoke hanging in the mountain valleys under the temperature inversion (fig. 32). On the west zone of the fire the inversion started to break about 1130 hrs and fire activity immediately started to increase. Fire in the vicinity of Mineral Hill had now backed all the way down into the bottom of Mineral Creek where it had been a very predictable and steady fire moving down slope during the past week (Bonney 1988). In the vicinity of the North Fork trail, Madison Creek and upper Lake Creek the fire had slopped over the control line west of Madison Creek during the night (Carlson 1988), under the influence of evening downslope winds caused by the dropping subsidence inversion. The prevailing southwesterly winds turned out of the east about 1700 hrs as the subsidence inversion

again dropped causing very dry, hot, downslope winds that lasted until 2000 hrs in some areas. At about 1900 hrs the fire became very active in the upper portion of the drainage just west of Madison Creek and in the lower part of the East Fork of Lake Creek. By 2000 hrs a major fire run pushed by strong east winds was crossing Lake Creek just below the East Fork of Lake Creek and moving up East Spread Mountain to the west. Fire behavior was principally a crown fire with 200 to 300 foot flame lengths and a rate-of spread of about 0.5 mi/h (40 chains/hr). The fire completed its run after about four hours of intense burning with extensive areas of active surface fire continuing throughout the night (Carlson 1988). During this east wind event the west zone fire activity picked up on all fronts, however the fire did not cross to the east side of the North Fork. Little fire activity occurred on the east side of the divide as crews continued to work spot fires and strengthen control lines with the aid of the east wind. Most of the newly burned acreage on this date resulted from the fire moving on to East Spread Mountain with 533 acres burned bringing the within perimeter total to 55,998 acres.

Figure 32. Sunrise from Morrel Peak Lookout (elevation 8,161 ft msl) to the west of the Canyon Creek Fire showing the inversion trapped smoke in the mountain valleys and aloft; otherwise the atmosphere was clear with normal mountain summer haze. Easterly winds during this period in early September carried the smoke well past Missoula, MT, which at times experienced up to a 90% smoke coverage. Photograph by Janet Spencer, Montana Department of State Lands, Morrel Peak Lookout.

During the September 2 morning briefing of the Regional Incident Coordinating Center (RICO) by the Fire Behavior Service Center (Bushey and Mutch 1991) a historic fire event was brought to the attention of the fire suppression community. Twenty-one years earlier, starting the afternoon of September 1, 1967, the Sundance Fire in northern Idaho made a 16-mile run in 9 hours with tragic results (Anderson 1968, Finklin 1973). During this same time period in 1967, major fire runs were also occurring in other locations in northwest Montana (Fischer 1969). Many of the same set of weather and fuel moisture circumstances which took place prior and during the 1967 incidents were again occurring in 1988 (Bushey 1989). Several ongoing fires were identified as having the potential to make major fire runs, including the Canyon Creek Fire.

September 3 was in many ways very similar to the previous day with the fire becoming active with the breakup of the morning temperature inversion and a late afternoon drop in the subsidence layer causing strong, easterly downslope winds. The high pressure ridge had gotten stronger and was nearly stationary, centered over the Idaho panhandle. At the surface, high pressure in southern Canada and east of the divide, and low pressure over the Washington and Oregon Coast, continued to create an easterly pressure gradient. Record and near record high temperatures in the upper 90 F range were being recorded throughout western Montana. On the west zone, fire in the bottom of Mineral Creek, and near the mouth of the East Fork of Mineral Creek, exhibited active torching and crowning behavior. The fire spread between 0.5 and 0.75 of a mile in this area with spot fires up to 0.25 mile ahead of the main fire. It appeared that the fire might move in the direction of Windy Pass (Bonney 1988). The fire in Lake Creek was also now positioned for a major run with the return to a westerly air flow. On the east side the fire remained relatively calm for the third day in a row. Crews on this side continued to construct handline and explosive fireline along the northwest side of the fire (Carlson 1988). Acreage burned on this date was also similar to the previous day's total, with 504 acres.

The RICO Fire Behavior Service Center in conjunction with other RICO Planning and Information positions, and staff from the Montana Governor's office started coordinating for the possible evacuation of fire camps and communities downwind from the numerous ongoing fire's of concern. Plans were also implemented to further restrict outdoor recreation activites in an attempt to prevent additional new ignitions during this time of extreme fire danger through the entire region. As a result evacuation and structural defense of downwind communities was begun, sometimes under Marshall Law, and restrictions on outdoor activities approved, including the delay of the upland game bird hunting season.

For the third day (September 4) the east winds continued over the northern Rocky Mountains, though the gradient was lessening as the surface high previously over eastern Montana moved east over the Dakotas. Afternoon high temperatures were slightly cooler than the day before, but still 10 to 20 F above normal. Fire crews continued to use the east winds to strengthen control features, with a burnout operation in the Lake Creek area producing the most active fire behavior experienced during the day (Carlson 1988). The day's fire activity increased the burned area by another 1,966 acres. During this Sunday afternoon the National Weather Service's Fire Weather Office in Missoula issued a "Red Flag Watch" for the upcoming Monday afternoon and Tuesday (September 5 and 6). This Watch was issued because of expected strong, shifting winds which would be associated with a dry-cold front passage which was expected to push the dome of surface and upper level high pressure east and away from the northern Intermountain West. A surface thermal heat trough was leading the front and was causing record high temperatures in eastern Oregon and Washington. These warmer temperatures were expected to be in northern Idaho and western Montana on September 5.

The National Weather Service and the Fire Behavior Service Center had been tracking the approach of the frontal passage from the Gulf of Alaska with the realization of the potential for extreme fire behavior on the wildfires in its path. During the morning of September 5, the Fire Behavior Service Center issued a Fire Behavior Warning to ongoing fires; in conjunction with the National Weather Service "Red Flag Watch" for strong, shifting winds associated with the expected arrival of a dry-cold front with critically dry fuels and extreme fire danger already in place. During the afternoon a special "Fire Fighter Notification of Extreme Fire Danger" was issued along with a news release of the developing situation and a Regional Fire Behavior Alert for extreme fire behavior conditions. During the evening the "Red Flag Watch" for gusty winds, low humidities, and warm temperatures was continued for western Montana and northern Idaho. A similar Watch was also issued for eastern Montana. The winds were expected to pick up during the evening as the front passed through western Montana.

Because the forecasted winds were now expected to arrive late this evening (September 5) or the next day, a burnout from the West Fork of Lake Creek was scheduled for the afternoon. However, control lines necessary for the operation could not be finished before 1600 hrs, and the burnout operation was scheduled to begin at that time (Carlson 1988). Part of the reason for the delay was due to the poor visibility caused by the smoke trapped beneath the temperature and subsidence inversions. It was also impossible to get the fire to burn well enough under these conditions to achieve the desired results. The inversions didn't start to lift until nearly 1300 hrs and as the sun penetrated the fire behavior began to increase. The burnout operation, needed to produce a large area relatively devoid of available fuel necessary to contain the fire, would never occur. The fire weather forecaster had warned that even though wind conditions would remain light they would become variable and constantly be changing their velocity and direction. At 1400 hrs on September 5, the fire activity in this area of the west zone started to increase noticeably, and at 1426 hrs a spot fire had developed across the control lines in the bottom of Lake Creek. During this same time period the wind direction was from the southeast at about 4 to 8 mi/h. The spot fire quickly grew to 0.5 acre in size. The radiant heat from the fire on the hillside to the east within the control lines was igniting the crowns of lodgepole pine ahead of the spot fire on the ground to the west (Carlson 1988). Fire crews in the area shifted "into the black," moving into previously burned areas designated as safety zones, to escape the rapidly developing fire. About 1600 hrs the wind direction shifted out of the northwest at 4 to 8 mi/h, and became oriented with the Lake Creek drainage. At the same time areas of fire up drainage from the spot fire became active and started moving toward the escaped fire. The convective activity reinforced the down drainage air flow and precipitated a major run down the bottom of Lake Creek. The fire run occurred in two distinct segments; the first fire moved down the creek bottom and hooked around the burnout line from the previous day, then moved upslope to the north into Madison Creek. Another area of fire developed behind the first and moved along the south side of the Lake Creek and up on to a northeast to northwest aspect of the adjacent slope and into the South Lake Timber Sale on the Lolo National Forest (Carlson 1988). By 1642 hrs the fire had entered into the timber sale area. At 1645 hrs the fire was declared a "blow-up" with very extreme fire behavior as the fire raced up slope through logged areas and standing timber. During the fire run the environmental conditions in the area were very favorable to active fire behavior; temperatures in the 80 to 85 F range, relative humidities between 8% and 12%, winds usually out of the southeast to south averaging 4-8 mi/h (Carlson 1988) with gusts around 20 mi/h, low afternoon 1-Hr Fuel moistures of 2% and 10-Hr Fuel moistures of 3% (fuel moistures from Monture RAWS and on site at 5600 and 7800 ft msl using the BEHAVE moisture module simulation program). By 1900 hrs the fire had moved as far east as the North Fork of the Blackfoot River and as far south as Section 29 in the timber sale (Carlson 1988). Jerry Williams, the Fire Management Officer for the Lolo National Forest, was flying over

the fire area at this time and observed the fire in the blow-up condition. The fire in the timber sale area was causing very strong convective activity and venting through the inversion layer which was trapping smoke beneath it. He watched smoke from as far away as Canyon Point, approximately 9 air miles to the north-northwest, being pulled horizontally down the various drainages toward the fire in the timber sale area. After dark the majority of the fire activity was in the South Lake Timber Sale as the fire completed its run to the ridgetops (Carlson 1988). At 2055 hrs the fire was reported by a ground observer to have "laid down" in the creek bottoms and moving real slow, "but on top by the clearcuts it's really boiling."

On the east zone, increased fire behavior began about 1300 hrs in the head of the Dearborn River and Red Slide Mountain as a section of fireline in that area was crossed and fire moved down drainage toward Welcome Creek. Other areas of fire in the east zone remained relatively inactive.

By the end of September 5, an additional 9,524 acres had burned, and additional acreage would continue to burn throughout the night. This brought the within perimeter acreage of the Canyon Creek Fire up to 67,993 acres.

Section 2.4 The Major Run - September 6 and 7

The National Weather Service changed the "Red Flag Watch" to a Warning in western Montana during the morning of September 6 because of the still anticipated arrival of the frontal system. The fronts position at 0900 hrs was on a line from about Bonners Ferry, ID to just west of Grangeville, ID. Winds from weather stations near the front were indicating surface speeds of 25 to 35 mi/h, similar to other dry-cold front passages during the summer of 1988. Fire Lookouts on the Kootenai National Forest in northwestern Montana reported morning wind speeds of 35 mi/h out of the southwest while calm conditions prevailed at the lower elevations. By 1200 hrs the front was on a line from west of Kalispell, MT to just east of Grangeville, ID and approaching the Canyon Creek Fire. At the Spotted Bear Lookout RAWS (Remote Automatic Weather Station), near the northwestern edge of the Bob Marshall Wilderness complex, 20-foot wind speeds had started to increase shortly after midnight and by 1300 hrs were averaging over 20 mi/h out of the southwest with maximum gusts to 48 mi/h. Average wind speeds at this high elevation station would remain 19 mi/h or greater for the next 33 hours reaching maximum gusts of 59 mi/h, mostly out of the west-southwest.

The day started in the west zone with a strong inversion in the North Fork of the Blackfoot River and Mc Dermott Creek drainages which did not begin to breakup until the low and mid-elevation winds started to increase with the approaching cold front at approximately 1230 hrs (Carlson 1988). The Silver King Lookout started to experience an increase in wind speed about 1145 hrs. As had been previously experienced the fire became immediately active as the inversion broke with 3- to 4-foot flame lengths from surface fuel beneath the tree canopy. This progressed rapidly to strong torching with flame lengths two times the tree heights. 1145 hrs also coincides with the first reports of major spotting fire behavior on the east side of the Blackfoot River. The first report of a convection column was made at 1315 hrs by the lookout on top of Silver King Mountain, at which time he was recording wind speeds of 18 mi/h with gusts into the 20 mi/h range. Winds were rapidly increasing at all locations on the fire. Other fires in the northern Rocky Mountains were also very active with running crown fire behavior by 1400 hrs (Bushey 1989, 1990). By 1600 hrs visibility at the Silver King Lookout was completely obscured by smoke to the north and west and was experiencing wind speeds in the 30 mi/h range.

At 1830 hrs the RICO Fire Behavior Service Center issued a "Special Fire Behavior Warning" based on analysis of the 1800 hrs Spokane, Washington radiosonde data. A reverse wind profile was indicated which Byram (1954) described as a low-level jet and classified as a Type 2-b wind profile. Where, or even if this jet-point might affect an ongoing fire was unknown but the Type 2-b profile was known as potentially very dangerous, especially during late afternoons and evenings in rolling or mountainous terrain. Being down wind of fires burning in heavy, dry fuel under this type of wind profile condition could be very dangerous. Indications from the radiosonde were that the jet-point was at an elevation that would interact with fires between 4,000 and 8,000 ft msl. The Canyon Creek Fire was currently burning in rugged terrain between approximately 4,800 and 8,200 ft msl elevation. All Forest Service Fire Dispatch Offices and Fire Camps connected to the Forest Service electronic mail system were issued the warning. This electronic message was followed up by personal telephone calls to all Dispatch Offices in northern Idaho and western Montana, as well as the District Offices at Lincoln and Choteau on the Canyon Creek Fire. The radiosonde for the same time period from Great Falls, MT showed a Type 4-a profile, a more normal wind profile with some strong winds. The lower elevations of the Great Falls radiosonde were being influenced by the presence of the northern Rocky Mountains which were producing a "wind shear" effect to the east with the wind speeds increasing rapidly above the mountains.

The initial strong winds from the southwest, caused part of the fire in the west zone to move up the east side of the North Fork of the Blackfoot River, and also up Mc Dermott Creek to the wilderness boundary (Carlson 1988). Explosive gases seemed to be causing the principal fire spread, with spotting up to 0.5 miles ahead. These spot fires however were being overrun by the fire front by the time they had grown to any size. Strong up drainage winds were being sucked into the fire and were likely fire induced. This portion of the fire ran approximately 5 miles to the east, reaching the East Fork of Mineral Creek which it spotted across. From this point the fire had only about another two miles to go before encountering a burned area from a fire run which had started in the Bugle Mountain area earlier the same afternoon. Wind shifts to the northwest later in the day caused some of this fire's southeast perimeter flank to temporarily become a fire front with some minor advances in that direction toward the summer residential community of Cooper's Lake. The fire also moved down the Blackfoot River halfway through Section 34 on the west side and into Section 2 on the east side. A strong northwest component of the wind exerted itself in the late afternoon on this portion of the fire, but the up canyon draft being created by the fire helped to negate the frontal winds and kept the fire from advancing very far down the Blackfoot River or Mc Dermott Creek (Carlson 1988) (figs. 33-34).

Figure 33. Late afternoon (time is unknown, possibly about 1700 hrs, darkness is due to the reproduction) September 6, 1988; Canyon Creek Fire convection column from the Lake Mountain Timber Sale Area and North Fork of the Blackfoot. The fire at this point is still producing enough energy to develop a strong vertical column before being sheared and blown west aloft. Smoke was to the north of Coopers Lake. Upper range of the wind speeds at this time were in the low 40 mi/h range on the fire. Photograph by Janet Spencer, Montana Department of State Lands, Morrel Peak Lookout, who reported that "the entire building was shaking" because of the strong, sustained winds.

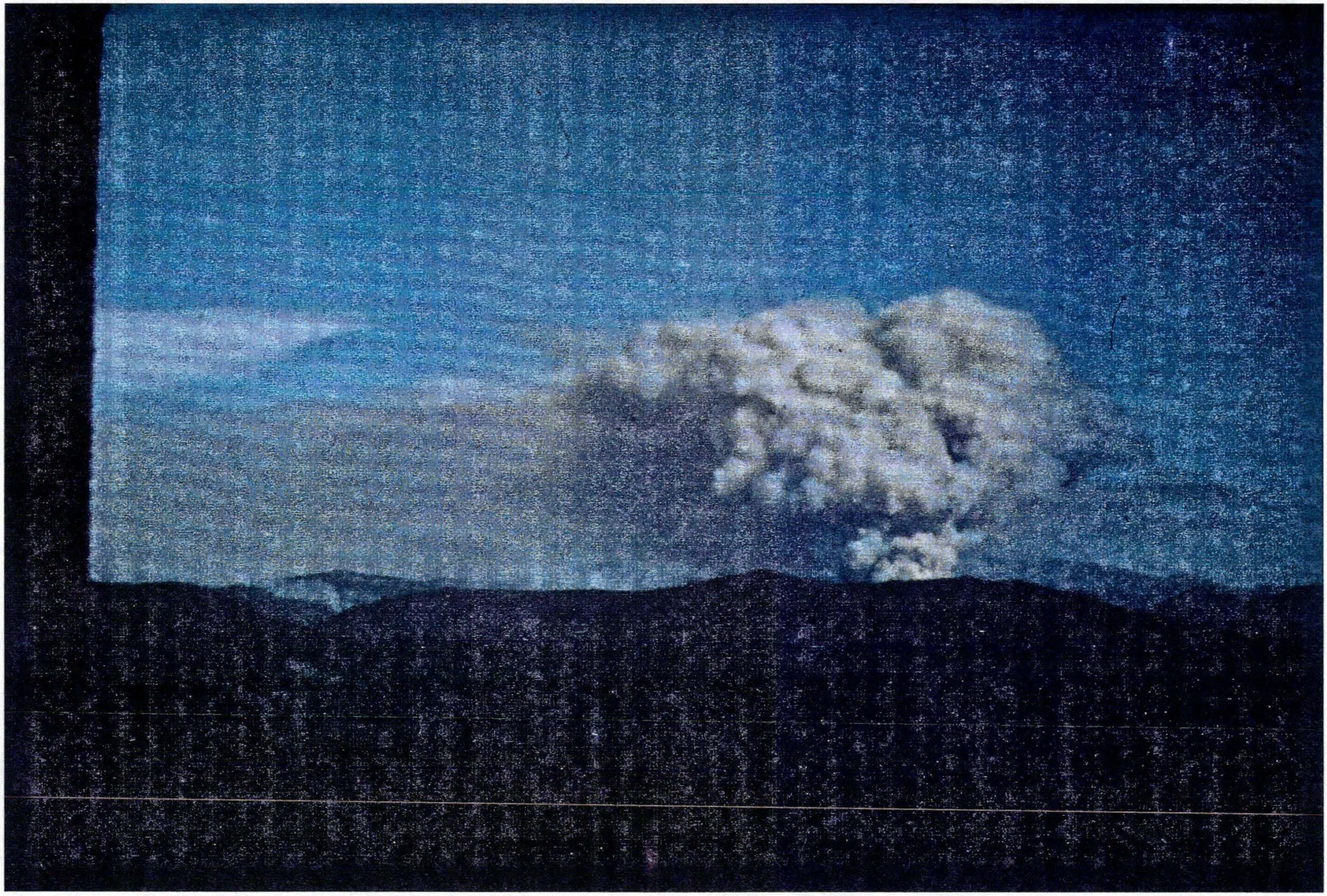


Figure 34. Canyon Creek Fire convection column photographed from the Morrel Peak Lookout at about sunset (1925 MDT); September 6, 1988. Wind speeds measured during this time period ranged from 40 to near 60 mi/h. The convection column (here seen through a 400 mm lens) is strongly sheared by the winds out of the southwest. Blurriness of the picture is attributed to the lookout building being shaken by the strong winds. Orientation is looking east-southeast. Photograph by Janet Spencer, Montana Department of State Lands, Morrel Lookout.

In the fire area along Lake Creek the afternoon range of environmental burning conditions were temperatures in the 75 to 80 F range, relative humidities 10% to 20%, winds west to northwest and averaging 15 to 20 mi/h with gusts to 30 mi/h (Carlson 1988), estimated 1-Hr Fuel moisture was down to 2% and 10-hr Fuel moisture down to 3%. As evening began, temperatures started to lower and the relative humidities began to rise with the passage of the frontal system, but the winds never decreased.

Fire activity in the Mineral Creek and Bugle Mountain area began to increase about 1200 hrs, and grew into a major run which burned throughout the night. It was in this general vicinity that the Silver King Lookout first noted the development of a strong convection column about 1315 hrs. As temperatures throughout the Scapegoat Wilderness rose into the upper 70's and lower 80 F range, relative humidities dropped into the low teens and both 1 and 10-hr Fuel moistures dropped below 5% (measured at Monture and Benchmark RAWS, at the Silver King Lookout, and on site using the BEHAVE moisture module simulation program) before the approaching frontal system causing the fire behavior to rapidly increase. Increasingly strong westerly winds, possibly associated with the reverse wind profile noted from the Spokane radiosonde and a surfacing jet stream, were oriented perfectly to push the fire from Bugle Mountain straight up the East Fork of the North Fork of the Blackfoot River, then across the Landers Fork over Sheep Mountain and Blacktail Pass onto the Lewis and Clark National Forest and into the Falls Creek drainage.

During the afternoon (1500 hrs) Jerry Burns, from the Lincoln Ranger District, Helena National Forest, volunteered to go into the Scapegoat Wilderness on horseback to retrieve a trail crew working in the Middle Fork portion of the Landers Fork who were threatened by the potential fire danger. Unknown at the time was how bad the fire situation was actually becoming. Burns would be riding right into the area in which the conflagration would be rapidly spreading in the East Fork and the Landers Fork.

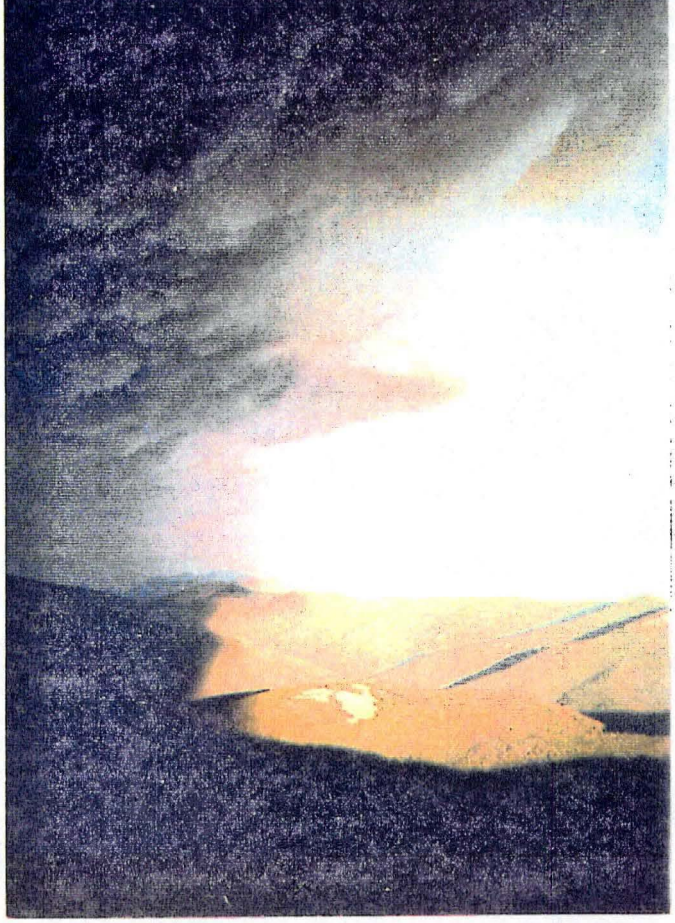
From 1800 hrs that evening until 0700 hrs the next morning the community of Great Falls, approximately 53 miles on the plains to the east, was covered beneath a thick, continuous layer of smoke that periodically reduced visibility to four miles. Falling ash was reported by the National Weather Service in that city for four hours between 0200 and 0600 hrs in the morning.

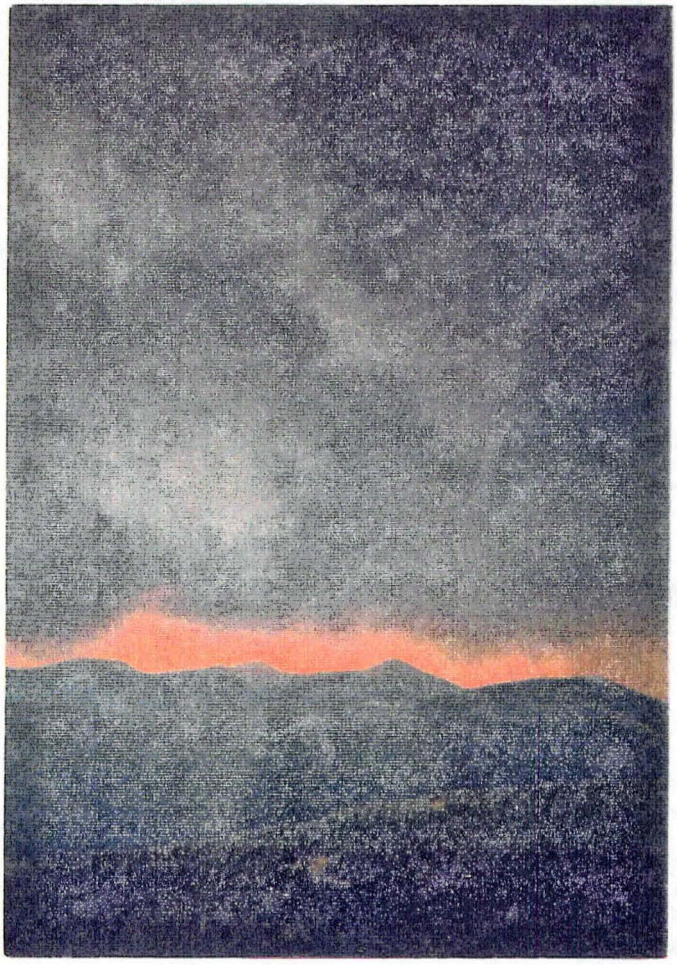
The fire run from Bugle Mountain appears to have begun shortly after an aerial observer noted the fire's position in that area at 1805 hrs. This appears to have been the principal location for the initial fire spread in this area, though additional hot spots and fire fronts existed on the fire perimeter to the north of this location as well. At 1720 hrs Jerry Burns could observe the convection column which appeared to cover most of the sky coming from the Bugle Mountain area (fig. 35). The smoke column angled from the ground in the west from behind the intervening mountains, rising at an angle in a solid, dense, dark black mass toward the east. As the smoke rose it changed from black to a dark gray color. The fire itself was not visible from Jerry Burns's viewpoint at the Indian Meadows Work Center trailhead. At about 1800 hrs Burns could just start to make out the glow of the fire as he crossed over a low divide on the trail at the head of Copper Creek. The fire was directly in his line of travel up the East Fork but still some distance away. The roaring from the fire was quite loud, making any other sounds difficult to distinguish. Shortly after this the aerial observer reported the fire coming over the ridge at a point south of Bugle Mountain. At 1840 hrs Burns and his horse passed the Webb Lake Guard Station and radioed a message to the Silver King Lookout that he had just met the foreman of the trail crew who was already heading out and packing bridging materials. Burns continued his search for the rest of the crew supposedly camped in the Middle Fork Creek above the junction with the Landers Fork. By 1900 hrs Burns

could observe the crown fire front heading in his direction up the East Fork of the Blackfoot River and south of Twin Lakes. The fire was burning up the drainage and quartering around a hill with the crown fire involving what appeared to be the entire south facing aspect. Because of the heavy timber Burns could not determine how fast the fire was traveling, but the very loud roar and the sudden strong wind shift toward the fire was a strong indication of the gravity of his situation. This fire had spread from the Mineral Creek area covering approximately 3 miles since the original 1315 hr observation by the Silver King Lookout. Assuming that the fire had reached the ridge of Bugle Mountain at 1805 hrs, about 2.7 miles had been covered by the fire during the previous 55 minutes (rate-of-spread 2.97 mi/h or 238 chains/hr). During the next ten minutes as Jerry Burns rode further on, he observed the fire moving toward him covering the next 1.5 miles in ten minutes (9 mi/h or 720 chains/hr). This crown fire was moving directly up the drainage in an easterly direction and had up to this time displayed an average rate-of-spread of 3.87 mi/h (310 chains/hr) for its entire run during the previous 65 minutes. To have achieved this high rate-of-spread the fire within the drainage would have had to been experiencing an up drainage wind speed of between 47 and 57 mi/h at the tree crown level under no slope conditions and was probably under the influence of the surfacing jet stream at this time. At Burns's location on the trail the wind was still being sucked into the rapidly approaching fire front and was snapping the boles of 8-10 inch DBH lodgepole pine on to the trail around him and his horse.

Figure 35. Terminator Line from the convection column of the Canyon Creek Fire as it moved eastward toward the grasslands, approximately 1600 hrs on September 6, 1988. This view from the Silver King Lookout looks north toward Blowout Mountain (7,667 ft msl), Red Mountain (7,161 ft msl), and Burned Point (7,690 ft msl). All three peaks are appropriately named; probably deriving their names from the fires of 1889 which also burned through the same country ninety-nine years and five days earlier. Photograph by John Wilson, Silver King Lookout, Helena National Forest.

Figure 36. Horizon aflame from the Canyon Creek Fire during the evening of September 6, 1988. This northwest view from the Silver King Lookout toward Olson Peak (8,881 ft msl) and Pyramid Peak (8,688 ft msl) in the center of the photograph shows the entire horizon on flame from the southern crown fire run originating in the Mineral Creek / Bugle Mountain area. From the light remaining in this view, an estimated time for the photograph would be between 1830 and 1915 hrs. This would place the time prior to sunset and after Jerry Burns and the trail crew had their southern escape route cut-off by the advancing flaming front. The front is about 11 miles distance from the lookout. Photograph by John Wilson, Silver King Lookout, Helena National Forest.





The fire moving up the East Fork of the Blackfoot was burning in a fuelbed with a typical surface fuel load represented by NFFL Fuel Model 10 (range NFFL Fuel Models 9 - 12) and an average crown biomass of 3.8 tons per acre (range 1.1 - 14.4 tons per acre). Using the methods presented by Rothermel (1991), the fire would have had a calculated average above crown flame length of about 100 feet, with an energy release of approximately 2,000 Btu/ft^2. It was a wind-driven fire with a unit power of fire/unit power of wind ratio of 0.25. In areas of localized NFFL Fuel Model 12 surface fuel loadings with crown biomass loads near the upper measured limits for timber stands in this area (Fire Group 9, mixtures of subalpine fir, Douglas-fir and lodgepole pine) the wind driven crown fire would have had an average above crown flame length close to 240 feet, with an energy release of approximately 7,500 Btu/ft^2.

Because it was obvious now that the fire would cut off the trail behind him in the East Fork, Burns radioed the trail crew and told them to head for Blacktail Pass and he would meet them at that location and then ride over the Continental Divide into the Dearborn River drainage. That was assuming that the fire didn't cut him off from the trail before he got there.

Fire spread in the more mountainous terrain north of the East Fork of the North Fork of the Blackfoot River was moving at a slower rate than within the drainage. It would take another 35 minutes (1945 hrs) before Jerry Burns would see the fire reach the ridgetops to the south of Pyramid Peak and to the west of the Landers Fork, a north/south oriented drainage. Burns met up with the trail crew at the junction of the Middle Fork and the Landers Fork and they finished packing up the camp on the horses and mules. Because of the mountain ridge to the west they couldn't see much of the fire but the sky was completely black with the convection column in all directions and they could hear the roar getting increasingly louder making verbal communication impossible. This portion of the fire front is estimated to have had a rate-of-spread of approximately 1.8 mi/h (145 chains/hr) during the previous 2 hours as it traveled up slopes, over ridges and on to adjacent slopes.

By this time, the fire in the more level East Fork drainage had passed the mouth of the Landers Fork. Jerry Burns and the trail crew had that southern escape route cutoff with fire now to the west and south of the trail up the Landers Fork drainage. During the next five minutes as the men and livestock moved upslope on the last trail toward the divide, the fire spotted with burning embers and gasses another 2.1 miles to the east moving the fire front across the Landers Fork drainage. The last trail across the Continental Divide was now burning and passage through was impossible, all trails out were severed by the rapidly spreading fire. One of these blazing gas balls traveled over the trail crew and exploded on the opposite slope "as if hit by napalm." The crew had no choice except to turn back toward the drainage junction from which they had just previously left. At that point they dropped the packs from the livestock and turned them loose, except for riding stock. Burns figured their only chance to survive was to reach a safety zone were the fire couldn't burn. They decided to make a dash for the talus slopes on top of Crow Mountain at the head of the Middle Fork Creek, a distance of over 3 miles and a climb of over 2,300 feet with areas of slope up to 70%. Both drainage slopes above and on either side of them were now burning and "lots of firebrands the size of 1 to 2 inch pieces of logs, pine cones and branches" were dropping around the men and on Crow Creek Ridge to their left. Wherever a burning firebrand dropped a new fire instantly sprung up and began to grow. With this additional spotting and ignition of the east slope above the Landers Fork the average rate-of-spread increased to 2.9 mi/h (234 chains/hr). To achieve this average rate-of-spread the fire in this rough terrain needed to have sustained, average winds between 35 to 42 mi/h. With the average crown biomass for the area and surface fuel loadings represented by NFFL Fuel Model 10, the average above crown flame length would have been about

80 feet, and in areas representative of heavier crown and surface fuel approximately 200 feet in length. Burns's visual estimate of the flame lengths at this time were between 300 to 400 feet which included the tree height (figs. 36 and 37). Calculated maximum spotting distance for the crown fire runs in either the drainage bottom of the East Fork or the more mountainous terrain surrounding the drainage would have varied with wind speed; 35 mi/h a distance of 1.1 miles, 45 mi/h a distance of 1.4 miles, 55 mi/h a distance of 1.7 miles and with wind speeds up to 65 mi/h firebrands could travel up to 2 miles.

Figure 37. Canyon Creek Fire photographed from the north of Augusta, MT approximately 1900 - 2000 hrs; September 6, 1988. This view of the convection column was taken from adjacent to Hiway 287 about 3 miles out of Augusta by Gilman Hill (1/2 way up Section 34, T20N, R6W) and looking toward the southwest. The convection column is clearly being influenced by the surfacing jet stream, possibly indicated earlier by the low level jet point shown on the 1800 hr Spokane radiosonde, which is shearing the column and preventing build-up into the more familiar erect, cumulus-type column. The foothills of the Front Range are just barely visible beneath the convection column and are about 14 miles distant. Haystack Butte would normally be within the orientation of this view, and it may be the base of this prominent 6,817 ft msl feature rising from the grasslands that is slightly visible above the foothills and beneath the smoke in the center of the photograph. Photograph by James Dolan, USFS, Northern Regional Office - Recreation, Wilderness and Lands.

At 2050 hrs Jerry Burns radioed the Silver King Lookout that he and the trail crew were trapped in the bottom of the Middle Fork Creek and were heading for the bottom of the Crow Mountain talus slope and that there was "nothing we can do for now." Because of the steep terrain the progress up the slope was slow. Several times they lost the trail and had to double back to relocate it. By 2110 hrs they radioed that they had made the rock slide, everyone was all right and they were trying to find a safer spot. Two of the three riding stock had run off in terror. From their vantage point it seemed that they had fire on all sides; Landers Creek, Mary Ann Creek and over Blacktail Pass. They continued to climb to the top of the ridge just south of Crow Mountain and stayed in the rocks on the east slope. Fire encircled them in all the surrounding drainages. Burns periodically looked over the ridgetop into Cooney Creek basin to the west which appeared to be completely on fire. The basin appeared to burn three different times, with the light from these fires completely lighting up the 8,000 ft elevation ridge on which the men were trapped. When Burns looked over the ridge edge it was difficult to stand because of the strong winds out of the west. The single mule which had also made it to the top with the men ran from side to side of the refuge looking for away out from the fires. The mule eventually gave up and simply stood still in terror. The men wrapped themselves up in horse blankets and spent a long, cold, windy night surrounded by fire as far as they could see. They would be lifted off the mountain ridge the next morning by helicopter. Amazingly all the livestock survived. The stock that had been turned loose or escaped were found two days later in a small, unburned area of the Middle Fork. The packs which had been discarded at the drainage junction were found to be completely burned, leaving only the metal hardware from the harnesses.

This portion of the Canyon Creek Fire continued to burn throughout the night in a east-northeast direction across the Continental Divide to the north of Caribou Peak, into the West Fork of Falls Creek, over the the north slope of Blowout Mountain and eventually ending its run at the timber edge on the top of Falls Creek Ridge. It is unknown what time during the next morning the fire reached Falls Creek Ridge. The entire length of this southern portion of the Canyon Creek Fire run covered a distance of about 20.8 miles. If the fire was able to sustain a spread rate of 2.9 mi/h it would have reached the end of the run in 5.5 hrs, or about 0115 hrs the morning of September 7.

While all of this fire activity was taking place on the western zone of the Canyon Creek Fire and spilling across the Continental Divide into the eastern zone the fire originally burning in the eastern zone was also active. Helicopter travel over the eastern zone into Welcome Creek during the morning of September 6th was very rough. Traveling 200 to 300 feet above the fire the winds were estimate to be 30 mi/h at 1000 hrs. A change in the wind pattern from previous days in this zone was very evident and more fire activity was occurring between 0900 and 1000 hrs than had taken place while the light east winds had blown. The helicopter pilot decided that the winds were to dangerous to attempt a landing at the helibase near the Welcome Creek Guard Station and left the fire area.

Fire crews were still positioned along Bald Bear Creek and along the edge of Pass Creek. Much of the area along the Dearborn River and between Bald Bear Creek and the Welcome Creek Guard Station had not had a chance to conduct burnout operations. The defensive fireline in this area was very weak to nonexistent. Because of the rapidly increasing fire behavior and the danger of fire crews being trapped by the flames, plans were made to pull the crews back into safer areas. The first crews to be moved were in the Pass Creek area. Spot fires were starting to heat up between the crews and the Elk Pass trail. A wind shift along the river bottom was the first evidence on the ground of a major change in environmental conditions on the fire in this area. This initial change was not evident at first to the fire crews on the adjacent timbered slopes because of the

wind protection the trees offered, but they could hear the wind blowing through the tree tops. The fire crews in Bald Bear Creek were then pulled out and tied in with the Redmond Hot Shot Crew above the Welcome Creek Guard Station. These 110 people established a safety zone in a mountain meadow. No radio contact was being made with the one remaining fire crew still out in Jackie Creek. When the fire started to run the six person crew in Jackie Creek decided their best course of action was to deploy their fire shelters (aluminum "pup tent"-like shelters to reflect back heat from a fire). They picked their safest spot and had the shelters open a good half hour before the fire reached their location.

The wind blew all night, and from a safety zone at the helispot on a gravel bar in the middle of the Dearborn River the firestorm glow grew and ebbed all night. The wind seemed to constantly be shifting directions down in the river bottoms and was quite loud. The wind blown crown fire passed right over all of the areas of mature lodgepole pine forest that had been underburned previously, throwing firebrands long distances beyond fire control lines.

It is unclear exactly when the fire run in the upper Dearborn River started but it was most likely between 1315 and 1445 hrs. This was the time period when the Silver King Lookout noticed a strong convection column building in the vicinity of Mineral Creek and the first reports by fire crews in the Dearborn of extreme fire behavior conditions. From the burn patterns evident from aerial photographs taken after the fire, the fire appears to have grown rapidly from many different sources along the extensive fire perimeters established on August 29 and 30. Burning patterns became very irregular throughout this northern fire run area because of complicated landscape patterns of vegetation and terrain. There appears to have been at least two separate major fire runs in the area generally north of the Dearborn River. The run most likely to have started first was near the fire crews at the head of the Dearborn drainage. This fire spread to the northeast initially, then later spread east and southeast staying for the most part north of Elk Creek. The second fire run was south of Elk Creek and initiated in the upper ends of Cataract and Bailey Basins. Calculated fire behavior for fire in these areas indicated that the wind driven crown fire would have had flame lengths above the tree crowns of 60 to 80 feet, and would have averaged a forward rate-of-spread of between 1.4 and 2.0 mi/h. (Average crown biomass of 5.5 tons per acre with a range from 0.3 to 12.1 tons per acre, surface fuel loadings were a complex mosaic of NFFL Fuel Models 9 and 10 with isolated pockets of heavier loadings more typical of Models 11 and 12. Calculations were made using the average crown biomass and surface Model 10, no slope conditions and average wind speeds of 30 mi/h.) Energy released would have approximately equaled 2,500 Btu/ft^2. Maximum spotting distances in the Dearborn drainage were lower than those obtained for the fire run in the East Fork of the North Fork of the Blackfoot River because of differences in forest cover heights, and ranged from 0.9 miles with a 35 mi/h wind speed, up to 1.8 miles with a potential 65 mi/h wind speed.

The southern edge of this northern portion of the fire run broke out of the mountain timber and on to the grassland plains above Bean Lake at approximately 2225 hrs after the fire had made a nearly direct easterly run of 6.8 miles from Cataract Basin. This portion of the fire had also been observed at the head of Pole Gulch at 2137 hrs and entered the grasslands by Bean Lake a little less than an hour later, a distance of about 2 miles in approximately 48 minutes. At the lower end of the calculated average rate-of-spread (1.4 mi/h) the entire eastern run of this fire would have lasted about 4.8 hours and have started about 1740 hrs. This portion of the fire spread fingers of fire out into the grasslands for another 3.5 miles. The northern edge of the fire above Elk Creek burned mostly to the northeast into the Smith Creek, Goss Creek and Blubber Creek drainages. Fire from these drainages burned out into the adjacent grasslands with Smith Creek being for the most part

the northern perimeter. The fire moved out of Blubber Creek and Elk Creek vigorously traveling another 7.2 miles in the grasslands; burning completely over the prominent geological landmark in the prairies called Haystack Butte and to within 4.8 miles of the community of Augusta.

It is very possible that different portions of the fire front that developed in the Dearborn drainage erupted into life at different times. Areas within the interior of the fire, especially along Elk Creek, were reportedly missed by the fire only to be hit several hours later by another passing fire front. The Elk Creek Fire Camp was one example of this phenomena. The main fire front on the south side of Elk Creek had spread past the camp about 5 hours earlier, when the mostly abandoned Fire Camp had to be defended from two different advancing fire fronts at 0200 hrs the morning of September 7 with water left in the camp shower systems. These two fronts appear to have been flanking fronts from the main fire runs to the north and south of the Elk Creek Fire Camp. It is possible that there was considerable interaction between the different advancing fronts causing increased and erratic fire behavior not accounted for by available fire behavior models.

Along most of the forest/grassland ecotone where the mountains give way to the plains the fire emerged between 2100 and 2300 hrs. Once into the grassland fuel the fire burned in typical wind driven fingering patterns. These grass fires were strongly influenced by the numerous bare ridges (reefs), small lakes, prominent streams, roads, heavily grazed pastures and irrigated fields which either tended to block or divert the fire spread. These barriers, combined with rising relative humidities and fine fuel moisture content eventually stopped the eastward spread of the fire.

As the sun rose on the day of September 7 the eastward spread had ceased, though the wind still blew. Most fire activity was now confined to the burnout of timbered areas within the fire's interior, which was almost completely surrounded by a large area of blackened grassland creating a natural barrier to additional perimeter spread. The fire suppression forces regrouped and started to evaluate the new fire situation after the rapid retreat and resulting confusion of the previous night. At the end of September 7, it was estimated that more than 180,000 acres had burned since the end of September 5, including considerable private, state and Bureau of Land Management lands. As it turned out this 180,000 acre figure was an over estimation, only 117,330 acres were later determined to have been burned during the two days and mostly during the night of September 6. This brought the Canyon Creek Fire acreage within perimeter to 185,323 acres. Cooler temperatures and higher humidities helped to limit new fire spread along timbered portions of the fire perimeter. Most of the fire in the Lake Mountain Timber Sale Area and Coopers Lake in the west zone was relatively quiet by 0230 hrs the morning of the September 7 even though the wind continued to blow. There just wasn't much fuel left in the direction the wind was blowing, it had already been burned. The strong winds prevented much flanking fire behavior and the main fire run in this area had long since merged with the burned area near Mineral Creek and Bugle Mountain. In the east zone the interior burnout of timbered fuel raised numerous individual smoke columns which with the declining surface wind speeds rose to higher elevation before being sheared off by the strong upper level winds. A Type 2-a wind profile (Byram 1954) was indicated by the 0600 hr Spokane radiosonde data, one of the most potential dangerous reverse wind profiles on a fire with a very strong jet point and this feature was emphasized in the continued RICO Fire Behavior Service Center Fire Behavior Warning. The fire crews which had retreated into safety zones the previous day hiked out of the burned area. Their safety concern no longer the fire, but wind-blown, fire-killed and weakened snags which could drop on top of them without a sound.

It was fortunate that another fire crew was not in the fire zone on these dates as well. At 1141 hrs on September 6, the Silver King Lookout had reported a spot fire on Blowout Mountain, most likely a

lightning holdover fire from storms which had tracked across the area during the middle of August. The increasing wind speed enabled the fire at this location to increase in behavior and become noticeable, as did other lightning holdovers in the northern Rocky Mountains (Bushey 1990). A National Guard helicopter with a fire crew was dispatched from the Lincoln Ranger District. On the way to the fire the helicopter developed difficulties and was forced to return to Lincoln without delivering the crew. Later that night much of Blowout Mountain was overrun by the Canyon Creek Fire.

A satellite photograph of the northern Rocky Mountains taken at approximately noon on September 7 clearly shows the smoke from the Canyon Creek Fire as a long tightly braided convection column stretching approximately 300 miles downwind of the Scapegoat Wilderness. The configuration of the plume is indicative of strong winds near the surface, probably a low level jet stream. A secondary frontal boundary was oriented on an east/west line across the fire, allowing the continuation of strong winds (Goens 1990). Clouds in the photograph are north of the frontal boundary. Other fire convection columns are visible in the satellite photograph as well; the Red Bench Fire in the Flathead National Forest and Glacier National Park, numerous fires in the Selway-Bitterroot Wilderness in western Montana and south into Yellowstone National Park (fig. 38). While many of these fires exhibited increased fire behavior due to the frontal winds, none grew to near the extent the Canyon Creek Fire did during that approximate 8 to 10 hour time period.

Figure 38. Northern Rocky Mountains from the Polar Orbiting Satellite (AVHRR) showing the Canyon Creek Fire convection column caught within the strong winds of a low level jet stream; September 7, 1988, approximately 1200 hrs. Other prominent fan-shaped convection columns are from fires burning south and east of the frontal system within Yellowstone National Park and the Selway-Wilderness.

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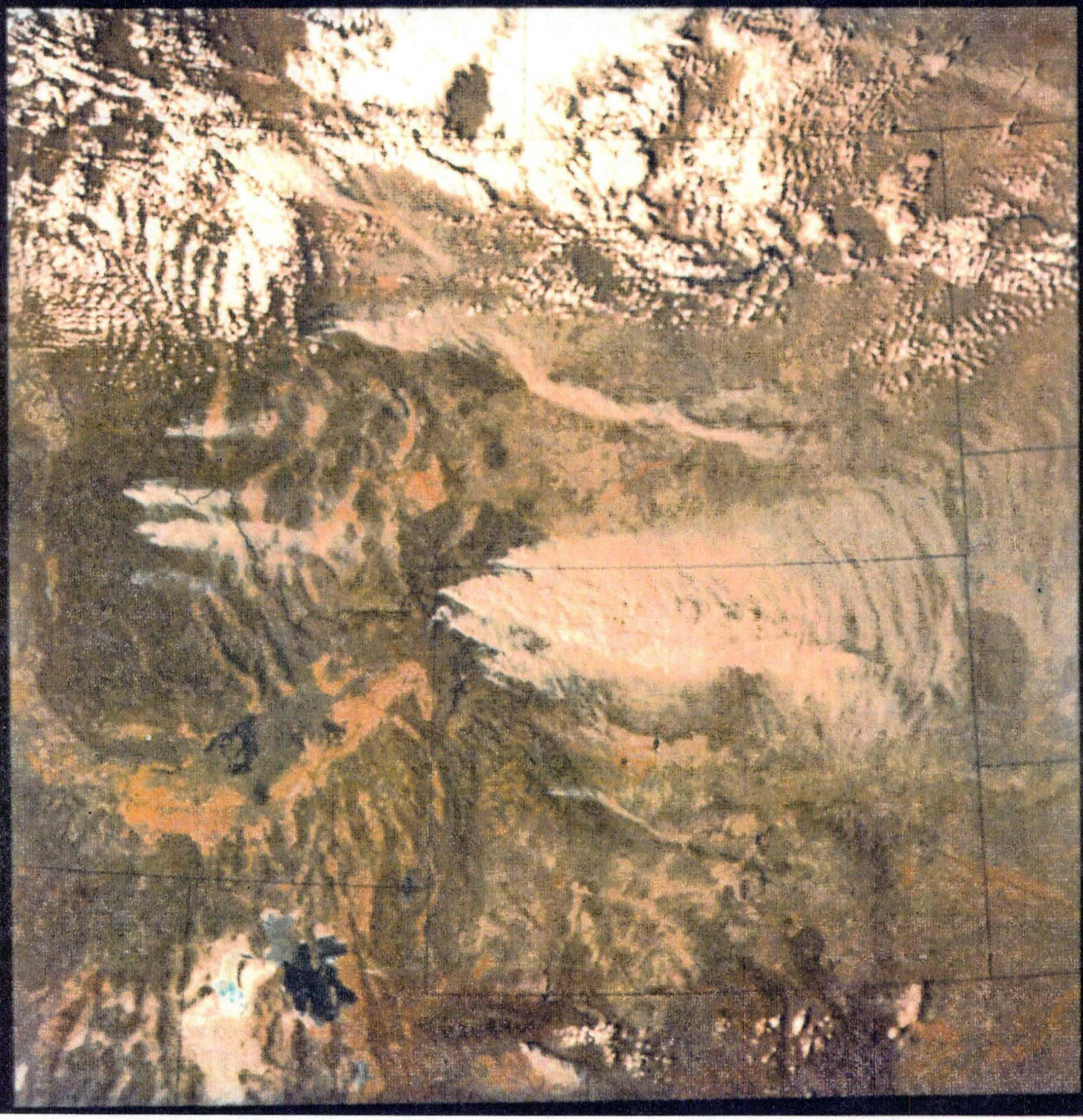

Large fire whirls and extensive timber blowdown have been mentioned as examples of extreme fire behavior on large fire runs, as was discovered on the 1967 Sundance Fire (Anderson 1968). Strong tree level winds blowing toward the Canyon Creek Fire were experienced by Jerry Burns which caused considerable blowdown with the snapping of tree boles, much of which was later consumed by the fire. Scattered surviving evidence for this type of activity could be found after the fire in the East Fork of the North Fork of the Blackfoot. It is likely this type of activity took place in other locations during the September 6 fire run as well, but was unwitnessed or evidence was not distinguishable from normal accumulations of downed timber. It has been estimated that winds in excess of 80 mi/h are necessary to cause timber blowdown (Anderson 1968). For the development of fire whirls strong enough to literally rip trees out by their roots and leave the blowdown timber scattered in a large circular pattern strong turbulent winds created by indrafts or eddy effects behind topographic features are necessary. Only one relative small area of blowdown timber on the Canyon Creek Fire exhibited the possible influence of large fire whirls, in the East Fork of Mineral Hill to the west of Bugle Mountain. This is in the general area where the fire run up the East Fork of the Blackfoot began, and may be evidence of the initial surfacing of the low-level jet stream and the influence of Mineral Hill providing the topographic influence for strong wind eddies. Additional evidence of large fire whirls, if they occurred, were destroyed by the fire.

Another interesting feature of the fire behavior during the burning period of September 6 and 7 involves areas unburnt between the main north fire run along the Dearborn and Elk Creek drainages, and the more southerly run starting near Mineral Creek and Bugle Mountain and burning up the East Fork toward Blowout Mountain and the Falls Creek drainage. The initial feature dividing these two fire runs was the previously mentioned 1979 Cabin Fire. This earlier fire had prevented the Canyon Creek Fire from spreading up the East Fork of the North Fork of the Blackfoot River. Fuel accumulation within this relatively recent, small fire (1,389 acres), was lacking and sufficiently discontinuous enough to prevent fire spread within much of the Cabin Fire perimeter. It is interesting to speculate how the 1979 fire might have influenced the spread of the 1988 Canyon Creek Fire had the earlier fire not been suppressed at great difficulty and expense. From examination of aerial photographs taken after the 1979 fire it can be seen that the Cabin Fire was following the burn mosaic pattern of a much earlier fire which had run to the northeast and ended at the Continental Divide. On September 6, 1988, there was a relatively small fire front from the Canyon Creek Fire which made a run of about 4.5 miles around the northern edge of the Cabin Fire mosaic before running into the natural barriers created by Crow Mountain and adjacent bare ridge tops. To the south of the Cabin Fire the main wind driven southern run took place, diverted slightly by the southeastern corner of the Cabin Fire. The initial diversion by the earlier burn mosaic, and the influence of the wind was sufficient to prevent the area between the Cabin Fire and Crow Mountain from being burned. When the main southern run encountered the southern ridge from Crow Mountain the fire was again diverted sufficiently to maintain its direction on a more easterly course, rather than northeast, as the wind appeared to have been driving it. There were several locations where the fire's direction of spread was blocked by natural barriers created by the southern ridge of Crow Mountain. If the fire had been able to pass over these barriers it would have entered into the Carmichael Basin and Grassy Hills area of the Dearborn River drainage to the northeast, an extensive area which has remained essentially fire free since before the extensive 1889 fires swept the same mountainous region.

Section 2.5 Final Stages of the Fire Season - September 8 to October 14

During the burning period of September 8th cooler temperatures and light winds calmed the fire in all areas. Most morning temperatures around the fire were in the 30 F range or cooler. Retartant drops and direct fire fighting was possible throughout the day on most perimeter and interior fire locations. No major fire runs were reported, in fact a burnout operation in the west zone was discontinued because they couldn't get the fire to successfully carry through the surface fuel in timbered areas (Carlson 1988) under the cool afternoon temperatures (upper 60's to mid 70 F range) and relatively moist humidities (lower 20% range).

During the afternoon of September 9, wind speeds started to increase with the approach of another cold front from the northwest. As temperatures warmed into the mid 70's to low 80 F range, relative humidities dropped into the teens and the formerly light wind speeds increased to 10 to 20 mi/h with gusts up to 30 mi/h, fire behavior again increased. The forecast had called for the potential of 50 mi/h winds with this dry-cold front passage, but the frontal system was not expected until later during the night. After the dry-cold front of September 6, this approaching cold front with more strong winds was an unwelcome forecast for the fire fighters and anticipated early arrival during the afternoon was even more ominous. In the west zone the fire activity increased (Carlson 1988), but the winds were lighter than predicted (8-12 mi/h with gusts to 30 mi/h) which mostly blew the fire back in upon itself. The weather station at the Lincoln Ranger District recorded 0.05 inches of rain fall as scattered showers started to occur, however this was the only measured precipitation. East of the Continental Divide no rain developed and the wind began to increase about 1300 hrs. By 1430 hrs strong sustained winds of approximately 25 to 30 mi/h started a crown fire run in the Falls Creek drainage. As the fire came down Falls Creek Canyon and jumped the fireline, it was also advancing to the east through Josylin Basin and around Cuniff Basin. At approximately 1730 hrs the fire broke over the ridge after traveling about 2.5 miles with flame lengths estimated to between 200 and 300 feet (including the tree height). After the fire cleared the ridge the forward rate-of-spread slowed considerably. During the fire run the Stanislus Hot Shot Crew were forced to deploy their fire shelters in Falls Creek. Several crew members sustained minor burns during the incident. This renewed fire activity resulted in burning an additional 3,358 acres. This brought the total within fire perimeter acreage to 188,071 acres and would represent the final increase in size of the Canyon Creek Fire.

After the passage of the frontal system, the next day's (September 10) temperatures were considerably cooler, reaching only into the upper 40's to mid 50 F range. Higher elevations north of the fire in the wilderness started to receive snow fall during the late morning hours. The Lookout on top of Beartop Mountain on the Rocky Mountain District of the Lewis and Clark National Forest radioed in "an order for Christmas decorations and a snow shovel." By 1315 hrs rain was reported on the Canyon Creek Fire. This was the first measurable moisture on some portions of the fire since August 7, 34 days earlier. The rain fell most of the night and at some locations it turned to snow, as much as 10 to 18 inches at places east of the divide. Crews on the east zone were moved to the National Guard facilities in Great Falls to escape the weather.

The Canyon Creek Fire continued to smolder at many locations throughout the rest of September whenever the sun came out and conditions dried slightly. But the precipitation event of September 10 was the long awaited end of the fire season in the Scapegoat Wilderness. A fire season that at many times seemed like it would never end, on this fire and the many others throughout western North America which had been burning for months during the summer of 1988. The Canyon Creek Fire was finally declared controlled on October 14, 112 days since lightning had stuck the

Douglas-fir in that small Montana wilderness drainage.

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Appendix 1. Canyon Creek Fire growth during the summer of 1988.

Date	Acreage
June 25	Lightning Strike
July 12	1
July 21	56
July 22	1,060
July 23	10,326
July 24	10,798
July 25	11,758
July 26	16,170
July 27	17,343
July 28	19,432
July 31	20,953
August 2	21,641
August 3	22,200
August 4	23,423
August 5	24,405
August 9	32,148
August 19	32,821
August 21	32,945
August 24	33,478
August 25	37,160
August 26	37,430
August 27	38,026
August 28	38,349
August 29	46,172
August 30	53,840
August 31	54,340
September 1	55,466
September 2	55,998
September 3	56,502
September 4	58,468
September 5	67,993
September 7	185,323
September 9	188,071

Appendix 2 (continued).

	LINCOLN RANGER STN		SEELEY LAKE RANGER STN		GLEASON'S RESORT		
DATE	ACTUAL ERC	3-DAY RUNNING MEAN ERC	ACTUAL ERC	3-DAY RUNNING MEAN ERC	ACTUAL ERC	3-DAY RUNNING MEAN ERC	EVENT
08/26	--	60.6	44	44.0	--	45.6	-Heavy rain east of the Divide
08/27	61	58.3	--	43.6	48	43.6	
08/28	62	60.0	44	43.6	51	51.0#	
08/29	64	62.6	44	44.6	55	54.0	-Fire crosses the Dearborn River and moves into Elk Creek, declared a wildfire, 46,172 acres
08/30	68	65.0#	46	45.3	--	56.6	-Extensive crown fire behavior continues, 53,840 acres
08/31	69	67.3	46	45.3	59	58.6	
09/01	71	69.0	45	44.6	60	60.0	
09/02	74	70.0	44	43.3	61	60.5	
09/03	73	71.00	--	42.6	62	61.0	
09/04	72	70.0	45	42.6	63	59.0	
09/05	72	69.5	45	43.0	61	60.0	-Blowup in the Lake Mtn timber sale area, 67,993 acres
09/06	72	70.0	44	43.3	62	60.6	-Large crown runs along entire eastern perimeter
09/07	73	69.0	43	42.6	63	62.6	-Extreme fire behavior ceases during the day, 185,323 acres
09/08	70	68.0	42	42.0	65	63.6	
09/09	68	62.0	41	34.3	65	64.5	-Fire run in the Falls Creek area, 188,071 acres
09/10	54	44.6	--	29.0	--	44.0	-Rain and snow begins to fall

Appendix 2 (continued).

	LINCOLN RANGER STN		SEELEY LAKE RANGER STN		GLEASON'S RESORT		
DATE	ACTUAL ERC	3-DAY RUNNING MEAN ERC	ACTUAL ERC	3-DAY RUNNING MEAN ERC	ACTUAL ERC	3-DAY RUNNING MEAN ERC	EVENT
09/11	0	30.6	21	23.6	24	25.5	-Rain and snow continues
09/12	26	23.0	23	27.6	31	27.0	
09/13	34	29.6	--	30.0	--	29.6	
09/14	--	34.3	31	33.3	34	32.0	
09/15	40	36.6	34	34.3	36	32.3	
09/16	43	37.5	33	28.6	32	27.6	
09/17	--	22.0	15	22.3	19	22.3	
09/18	11	9.5	--	15.3	--	16.0	
09/19	12	11.6	14	16.3	0	15.0	
09/20	17	16.3	18	19.0	--	17.3	
09/21	22	20.6	23	23.0	27	22.0	
09/22	24	24.0	24	26.0	--	25.6	
09/23	26	26.6	26	29.0	26	25.6	
09/24	32	28.6	30	30.6	--	24.6	
09/25	33	31.6	30	31.0	24	23.3	
09/26	35	27.6	27	25.0	23	21.3	
09/27	0	25.3	0	21.0	0	18.3	
09/28	24	23.6	17	19.3	15	19.3	
09/29	29	28.0	22	23.3	--	21.6	
09/30	30	30.3	25	26.0	27		
10/01		31.3		27.3			
10/02		33.0		27.0			
10/03		34.6		27.0			
10/04		35.6		26.0			
10/05		36.3		30.0			
10/06		36.6		30.5			
10/07		37.0		30.6			
10/08		38.6		31.3			
10/09		39.3		30.6			
10/10		40.0		29.6			
10/11		39.0		28.3			
10/12		39.3		28.3			
10/13		38.3		27.3			
10/14		34.6		21.3			
10/15		23.0		13.3			
10/16		13.6		7.3			
10/17		8.6		6.0			
10/18		8.6					
10/19		7.0					
10/20		7.0					
10/21		9.3					
10/22		12.5					
10/23		15.5					
10/24		19.0					

Appendix 2. 1988 ERC levels for stations near the Scapegoat Wilderness.

	LINCOLN RANGER STN		SEELEY LAKE RANGER STN		GLEASON'S RESORT		
DATE	ACTUAL ERC	3-DAY RUNNING MEAN ERC	ACTUAL ERC	3-DAY RUNNING MEAN ERC	ACTUAL ERC	3-DAY RUNNING MEAN ERC	EVENT
06/25	48	40.6	35	33.6	40	36.6*	-Lightning strike
06/26	--	39.0	28	33.3	31	34.3	
06/27	--	36.3	33	30.3	32	31.3	
06/28	38	34.3	29	30.0	--	24.0	
06/29	32	35.3	28	29.3	0	20.0	-Decision Notice
06/30	43	37.0	--	30.6	20	17.3	
07/01	44	40.6	33	33.3	24	22.6	-Level 1 Analysis started
07/02	44	41.3	35	34.3	26	25.0	
07/03	45	40.3	35	35.0	28	23.3	
07/04	41	33.3	--	33.3	18	20.0	
07/05	19	32.3	31	32.0	16	19.3	
07/06	--	33.3	--	32.0	--	22.6	
07/07	40	41.0	34	34.6*	28	27.6	
07/08	--	42.8	38	38.0*	31	30.3	-Fire is <1 acre, not active
07/09	40	43.6	44	40.5@	33	32.0	
07/10	46	43.3	41	41.3@	34	33.3	
07/11	43	43.3	40	40.6	34	33.3*	
07/12	44	42.6	39	37.6	34	35.3*	-Level 1 Analysis approved
07/13	43	41.6	33	32.6	39	36.0	
07/14	39	41.0	25	31.1	37	37.3	
07/15	43	41.6	--	32.6	38	36.6	
07/16	45	43.6	--	37.0*	38	38.0	
07/17	46	45.3	--	38.6*	41	38.3	
07/18	48	46.3	40	39.6	39	38.6	
07/19	48	47.6*	40	40.6@	--	39.0@	
07/20	--	49.3*	--	42.0@	--	41.0@	
07/21	52	52.0	44	43.3	47	43.6	-1st fire run
07/22	55	54.6	44	44.6	49	45.3	-Fire 56 acres
07/23	58	56.0	46	46.6	--	46.3	-Cabin Creek fire run, 10,382 acres
07/24	57	57.0@	46	47.3#	50	45.6	
07/25	59	57.6	47	47.3	49	47.0	

Appendix 2 (continued).

	LINCOLN RANGER STN		SEELEY LAKE RANGER STN		GLEASON'S RESORT		
DATE	ACTUAL ERC	3-DAY RUNNING MEAN ERC	ACTUAL ERC	3-DAY RUNNING MEAN ERC	ACTUAL ERC	3-DAY RUNNING MEAN ERC	EVENT
07/26	60	59.0	45	47.6	55	48.3#	-Fire moves onto the Helena NF following the N. Fork, 16,170 acres
07/27	61	60.0	48	48.3	54	51.6	
07/28	61	61.0	48	48.3	56	53.3	
07/29	62	61.3	--	48.0	57	55.6	
07/30	62	61.6	47	49.0	61	56.3	
07/31	63	61.6	52	49.6	59	56.6	
08/01	63	60.3	50	50.3	59	54.3	
08/02	59	57.6	48	49.0	54	52.3	
08/03	55	56.3	48	48.0	--	51.0	
08/04	59	57.3	--	48.0	54	52.0	
08/05	55	58.6	49	45.6	--	53.3	
08/06	61	60.0	41	44.3	56	52.3	
08/07	65	59.6	--	43.0	52	51.0	
08/08	62	61.3	45	44.6	53	51.0	
08/09	66	62.3	46	45.6	57	53.6	-Tobacco Valley fire run crosses the Divide, 32,148 acres
08/10	66	64.6#	46	46.3	59	55.3	
08/11	68	60.3	47	46.3	57	55.6	
08/12	53	57.6	47	46.0	57	53.3	
08/13	59	53.5@	45	45.0	52	51.6	
08/14	--	58.5	--	44.6	52	50.6	-Scattered rain showers
08/15	62	59.5	44	43.0	54	49.6	
08/16	61	60.0	40	42.3	50	48.3	
08/17	64	61.0	42	42.0	48	48.3	-Light rain
08/18	64	62.6	44	43.0	54	50.3	
08/19	66	63.6#	43	43.6	55	52.0	-Fire moves toward the Dearborn River, 32,821 acres
08/20	66	64.0	43	42.3	54	52.0	
08/21	--	64.5	40	42.3	53	51.3	
08/22	67	65.5	43	42.6	54	52.3	
08/23	69	66.3	45	44.3	55	54.6	
08/24	71	67.0	45	45.0	59	56.6	
08/25	70	64.0	--	44.6	58	49.3	

Appendix 2 (continued).

	LINCOLN RANGER STN		SEELEY LAKE RANGER STN		GLEASON'S RESORT		
DATE	ACTUAL ERC	3-DAY RUNNING MEAN ERC	ACTUAL ERC	3-DAY RUNNING MEAN ERC	ACTUAL ERC	3-DAY RUNNING MEAN ERC	EVENT
10/25		20.5					
10/26		19.0					

* Exceeds the 1973-1987 80th percentile level.
@ Exceeds the 1973-1987 90th percentile level.
\# Exceeds the 1973-1987 97th percentile level.